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Metals and Alloys

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Feature Section

Friction Devices of Metal Powders

One of the most interesting applications of sintered metal powders on a really large scale is described in the first article. Alloys of metal powders are firmly bound to steel backings which are used as friction devices on many types of machinery. The metallurgy, the heat treatment, and the equipment used are fully described. The history of this development and the problems solved are discussed.

Induction Heating

It is generally known that induction heating is widely used in several applications in industry, particularly melting, heat treating and forging. Mr. Chesnut has presented in one general discussion a picture of the many uses of this type of heat, particularly as it affects the Defense Program.

Open-Hearth Problems

This article is a valuable contribution to the literature on open-hearth practice. It contains comment on certain papers presented earlier this year and also a broad discussion of slag metal relations.

Calcium in Ca-Pb Alloys

An exceedingly unique method of determining the amount of calcium in calcium-lead alloys is described by Messrs. Schumacher and Bouton. The calcium content is determined by inspection—it is a case in which the eye is quicker than the microscope.

Gold Filled Metal for Spectacles

The many steps necessary in the manufacture of gold filled spectacles by the American Optical Co. are told in a pictorial presentation. All the steps, from the selection of raw materials to the final shaping and assembly of the finished parts of the spectacles, are covered.

Engineering Digests

Flame-Cutting Shell Billets

Not the least interesting feature of shell manufacture is the variety of processing methods that can be—and are—employed. Flame-cutting of forging billets, many of which are destined to be shells, is described by Rockefeller (page 898).

American Calcium

All kinds of new American industries are the children of the defense program and strategic necessity. A recent addition to the family is calcium, which, according to Kinzel (page 903), is now being produced on a commercial scale at a plant in Michigan.

Annealing, Flakes and Hydrogen

Flake formation—always a dominant problem in time of war—has been assiduously studied by American metallurgists and engineers, who have tended to point their guns at hydrogen. Interesting German investigations on the effect of hydrogen absorbed on annealing are reported by Houdremont & Schrader (page 914).

Welding Aluminum

As ever-faster aircraft are developed, the effect of even such tiny surface bumps as rivet heads on aerodynamic drag becomes appreciable, and spot welding of aluminum aircraft structures is, therefore, on the increase, says Merriman in a "composite" on the welding of aluminum, beginning on page 916.

Bright Anneal Brass?

Yes, brass can be "bright annealed" by using an inert or strongly reducing gas, but commercial practice largely follows the procedure of "clean annealing"—annealing in an inexpensive atmosphere that permits a thin, easily-pickled-off oxide film to form, report de Coriolis & Lehrer (page 923).

Metals in German Aero Engines

The Germans—up to 1939, at least—have been using the highest grade materials and workmanship in their aircraft engines, it is revealed by Young (page 928), reporting on a *real* "teardown" inspection of a German engine.

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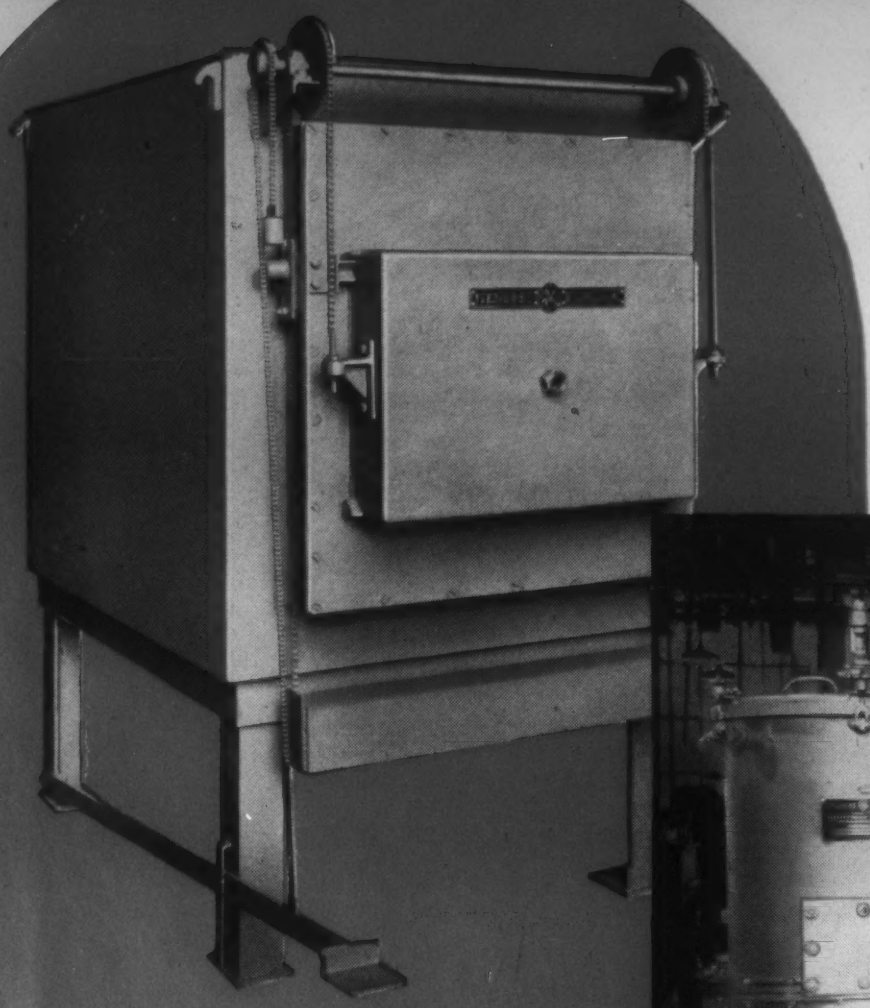

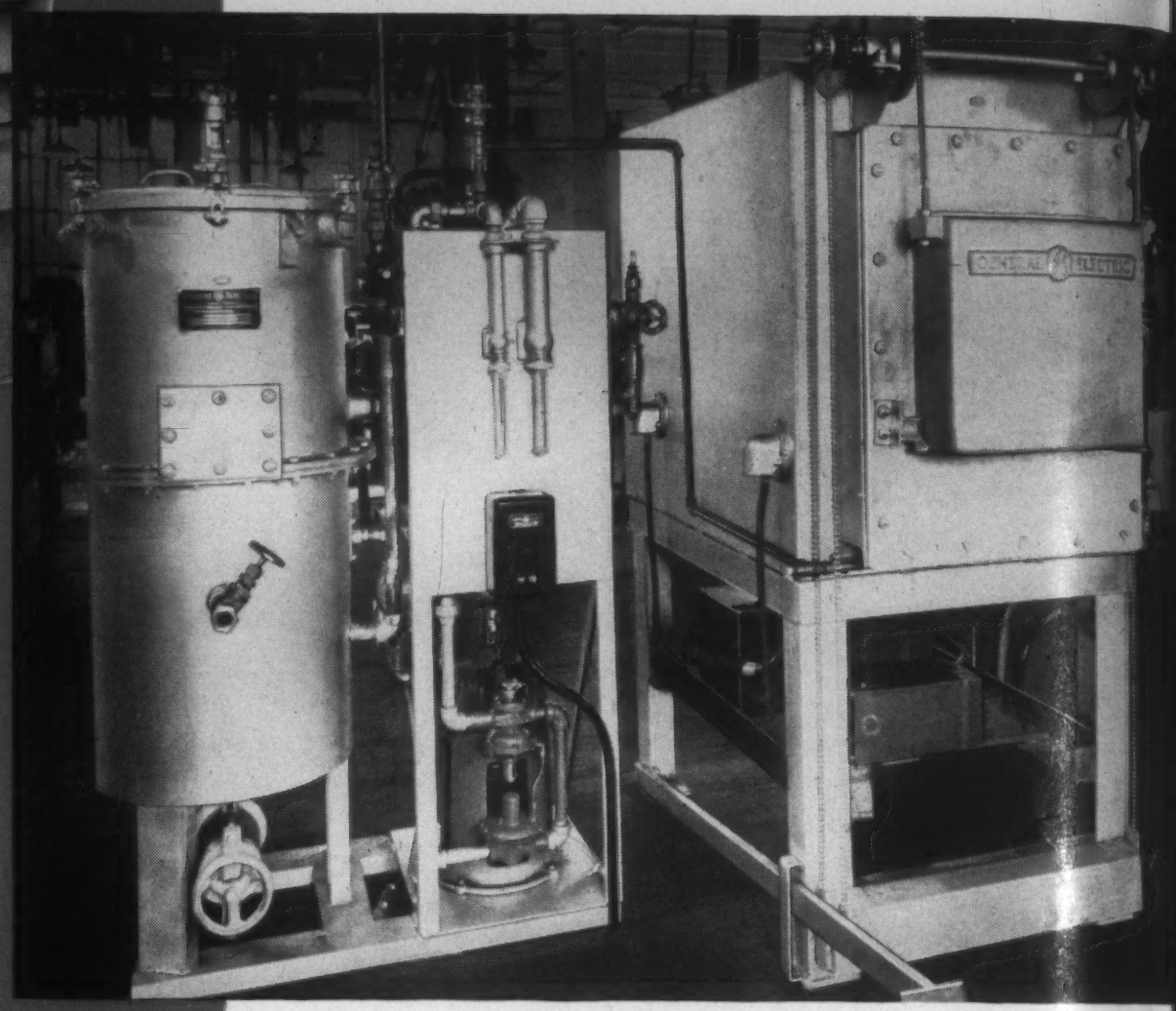

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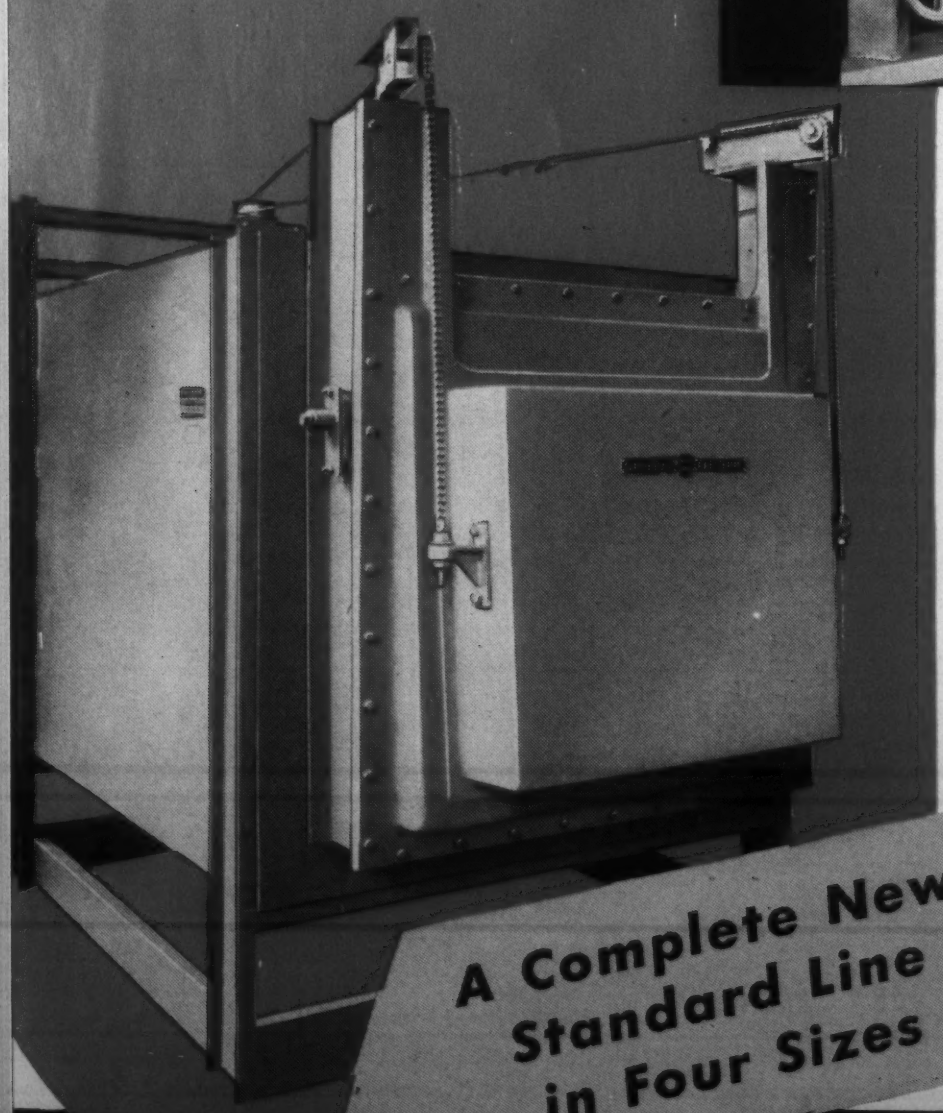

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GENERAL ELECTRIC

Isn't the Pendulum Swinging Too Far?

Things have a way of balancing themselves. The strong effort of the steel producers to cut down the compositions and sizes passing through the mills, in order to facilitate quantity production, is logical and the step important in the defense program. Yet, such simplification carried out completely and becoming stabilized enough to carry through beyond the period of emergency, is not a permanently healthy condition. If customers, seeking for the most effective and economical steel to meet a particular type of service, cannot secure trial lots of special steels, but are forced to select only from the steels of huge quantity production, the progress of the metallurgical engineering achievements in making and using "tailor-made" steels will slow down almost to a standstill.

However, with electric steel capacity now planned for almost 4,000,000 net tons, this certainly need not be the case. When the emergency is over, these electric steel furnaces will be looking for something to melt. These greatly increased facilities for making up moderate sized heats of special compositions with a minimum of difficulty should lead to catering to the demand for experimental and tailor-made steels. As far as the melting end goes, the situation will automatically adjust itself. There is likely still to be a lack of comparably flexible rolling equipment on which a variety of shapes and sizes can be made more conveniently than in a production mill.

There would seem to be opportunity for some mills to build up a special-order department, using low-output hand mills that would be obsolete in the main mill, to go with the electric furnaces.

Some of the publicity on the handicap of handling small lots may be to lay the ground work for charging extras on small lots that, in time of low production, the mills omitted. That's all right. The chap who needs a special lot should pay for the bother of making it and keeping it separate from other lots. It is the setting up of permanent barriers to his obtaining it when he's willing to pay for it that needs watching.—H.W.G.

Metal Powders

One of the pioneers in the powder metallurgy industry, Charles Hardy, has called our attention to some of the loose terminology prevalent in this field. The base materials in this industry are produced by different methods—some by mechanical and some by chemical. Those made by the first are really powdered metals; those by the second, metal powder or metals in powdered form.

To designate all these by the term "powdered metals" is considered less desirable and less accurate than to use the term "metal powders" for the entire base product. It is, therefore, urged that editors and others in the field adopt the term "metal powders." We second the motion.

Of course, the use of the expression "powdered metallurgy" is incongruous, but it is still prevalent, even from professors in institutions of learning, though it surely wouldn't pass the Dept. of English. —E. F. C.

Engineer and Metallurgist—Incorporated

Stories of that mythical battle between the metallurgist and the engineer are again current at technical society meetings and conventions. We listened to a particularly entertaining one at the recent National Metal Congress.

For some reason, people insist on cooking-up an elaborate bone of contention between these two vaguely separated groups of technical men. They explain the lack of cooperation that exists between the two and the enormous waste and inefficiency that might result if this condition were allowed to continue. Then, depending on which side of the fence they, themselves, are located, they indulge in much sharp and subtle lampooning of this fanciful obstruction.

All of it makes good platform talk and is sure to get a rise out of the audience, but factually it just doesn't stand up.

What is seldom realized is that a fine line can no longer be drawn separating the metallurgist and the engineer, because a technical man that is really a combination of both has evolved. This man, whom we like to call the metallurgical engineer, was prob-

(Continued on page 876)

Refugee kiddies inspect a new ambulance presented by the British-American Ambulance Corps.

Some Inland Defense Steel Goes on Errands of Mercy

Every day Inland ships thousands of tons of steel for the Defense Program. A large part of the tonnage is used for constructing new plants, building equipment and manufacturing munitions. However, some Inland Defense Steel goes on errands of mercy. Typical of this are the Inland Sheets used by automobile manufacturers in building ambulances for service not only in our own army camps, but also in the camps and among the civilian populations over seas.

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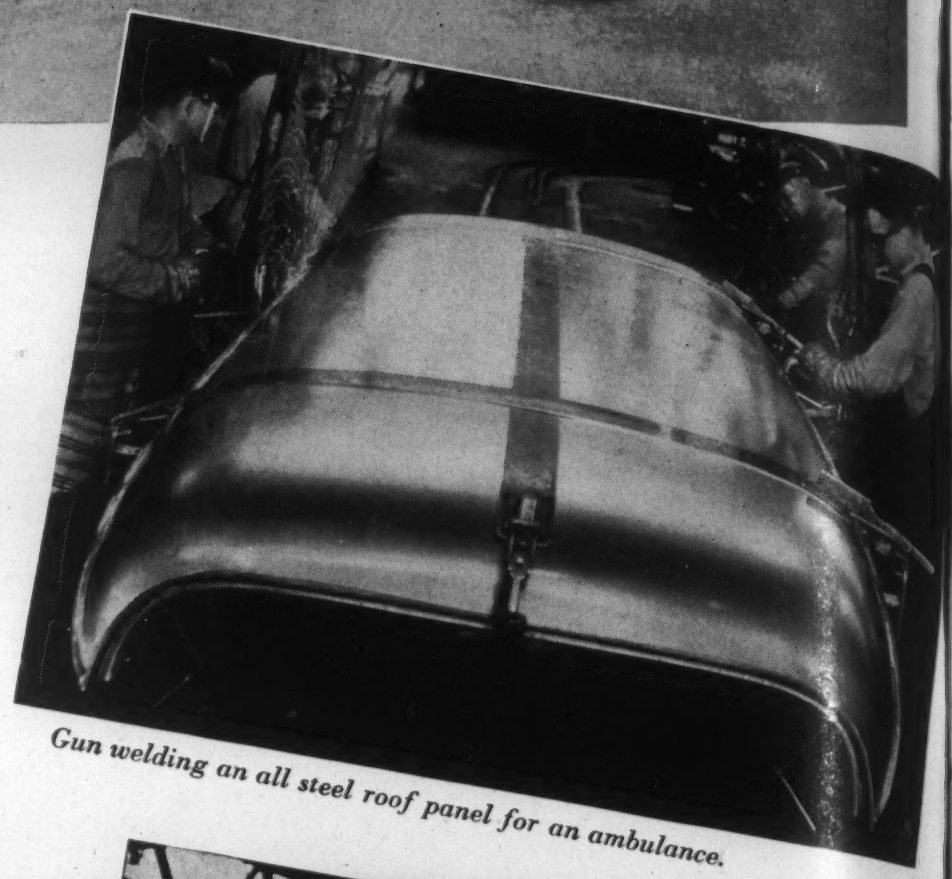
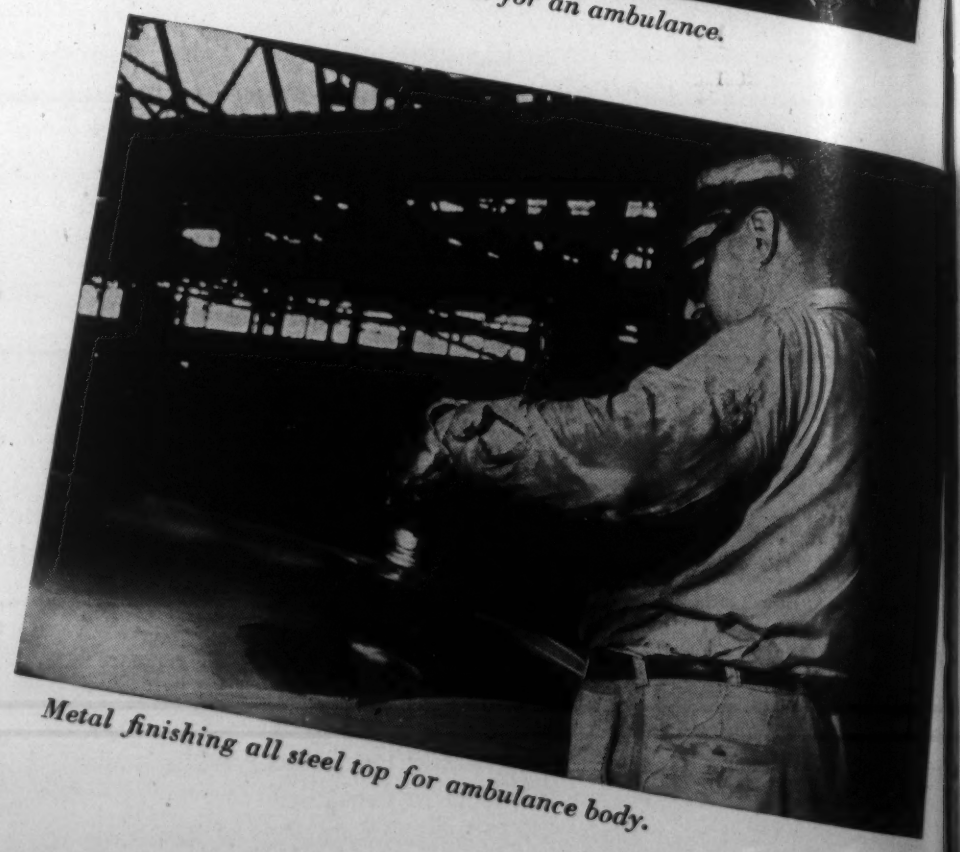


Gun welding an all steel roof panel for an ambulance.



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Sintered Metals in Friction Devices

by EDWIN F. CONE

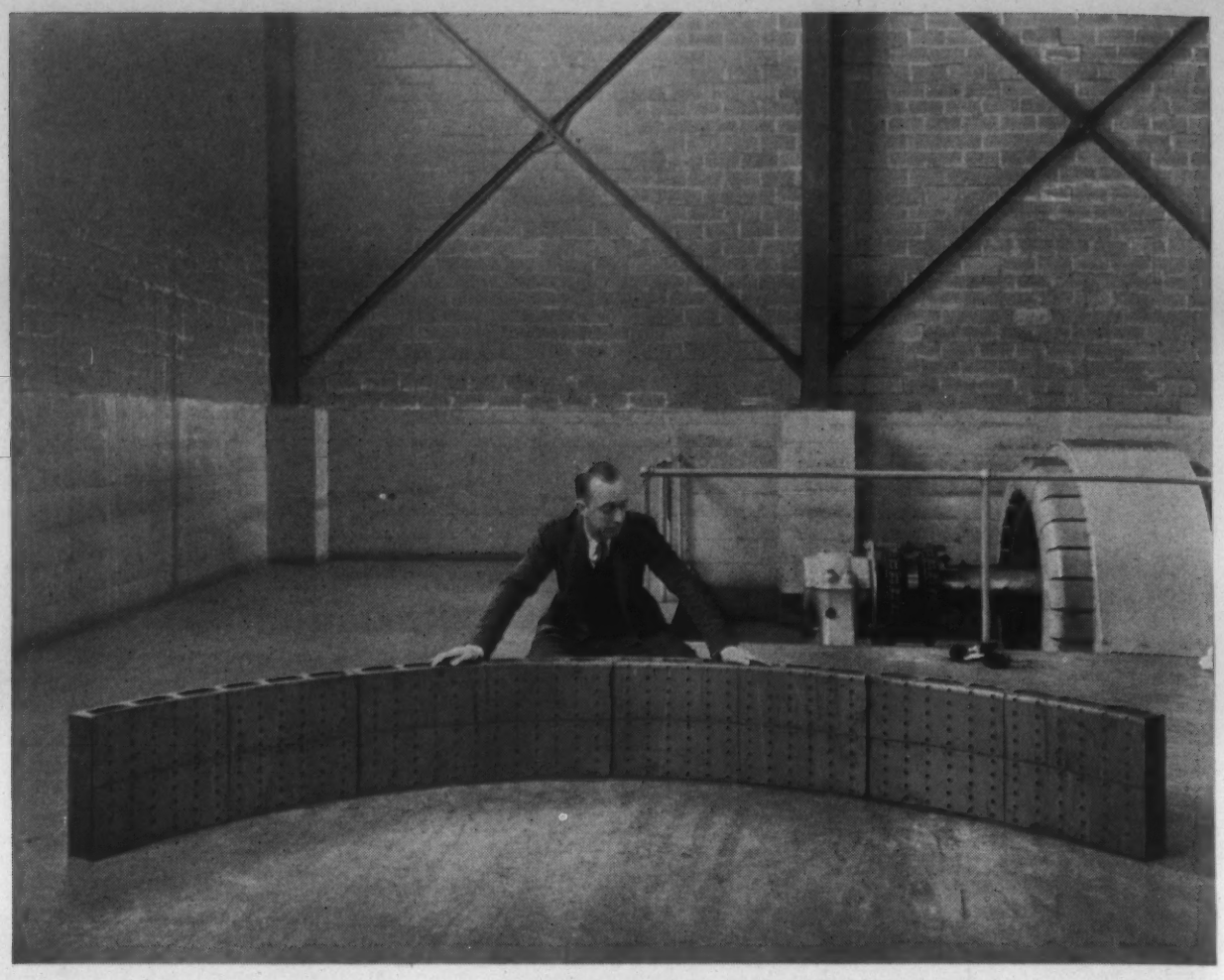
Interest in powder metallurgy is one of the prominent trends of the past few years. In the last two years two national symposiums of broad interest and value have been held.

This article is a contribution to the literature in this field. The production of the sintered metal friction devices here described demonstrates one of the outstanding accomplishments in the application of powdered metals to the design and production of valuable engineering products. The history of the development of this product by the S. K. Wellman Co., the problems solved, the heat-treating and other equipment developed, some of the alloys used, and certain industrial applications are discussed.

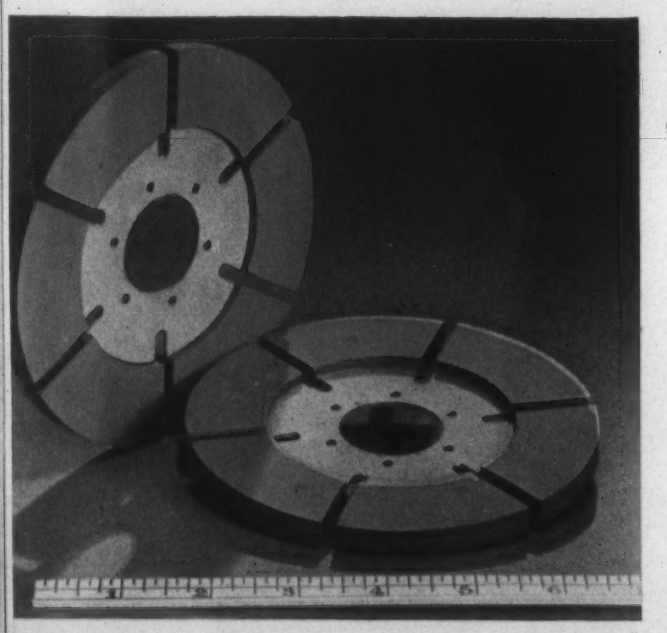
WITHIN THE LAST 20 YEARS powder metallurgy has gradually gained marked recognition. Today it is attracting wide attention, both metallurgically and industrially. It has long been known that a wide variety of articles could be made by sintering metal powders into a coherent form, but it is only within the last decade or two that the use of powder metallurgy for the production of important industrial products has become extensive.

Sintered bearings of the self-lubricating type have been in wide use in the automotive industry and in allied industries for the past 15 years, and have more recently been given wide acceptance in the refrigeration and electric motor industries. Today such bearings consume an extensive part of the relatively large quantities of metal powders which are being produced.

Of more recent development, however, are brake and clutch facings composed of sintered metal powders. Such brake and clutch facings have been available since the early 1930's, but only within the past five or six years have they come into extensive use. Today they are being used in the heavy industries from coast to coast and have found important uses in many of the war machines which are being produced under the Defense Program. Trucks, tractors, tanks and airplanes are now being produced which rely on sintered metal clutches or brakes to

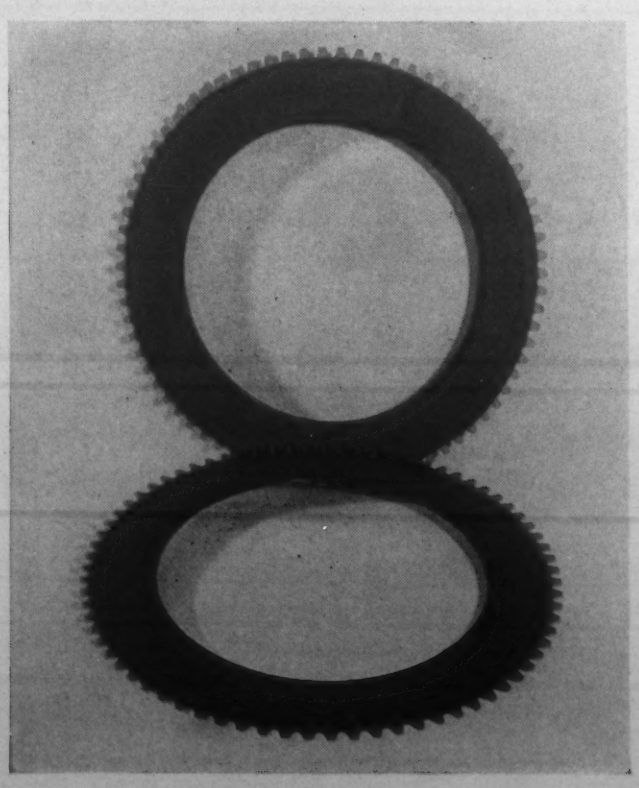


Velvetouch bimetallic facings riveted onto a brake assembly for a mine hoist.

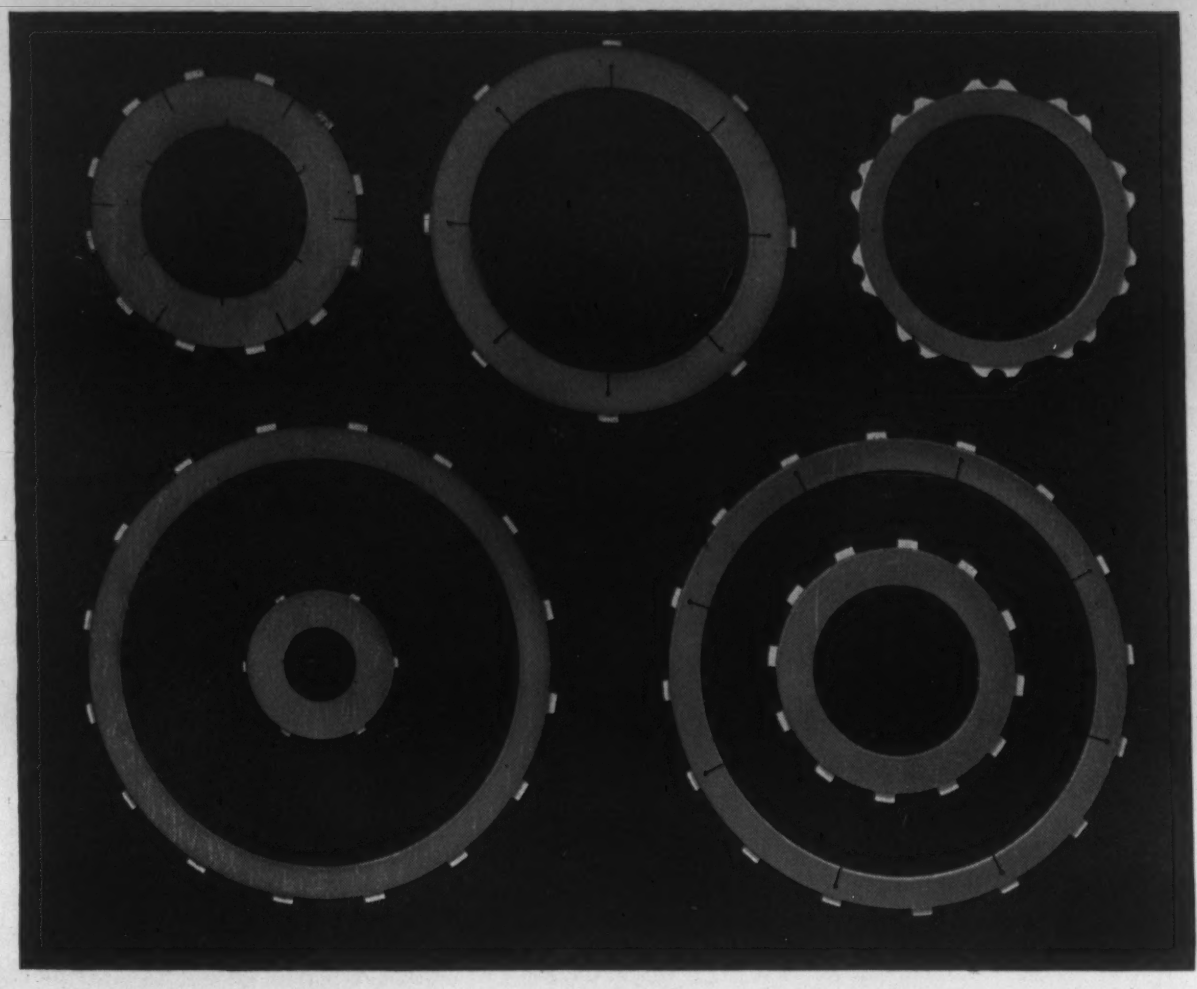


Clutch disks for truck with Velvetouch facings welded to the steel carrier disk.

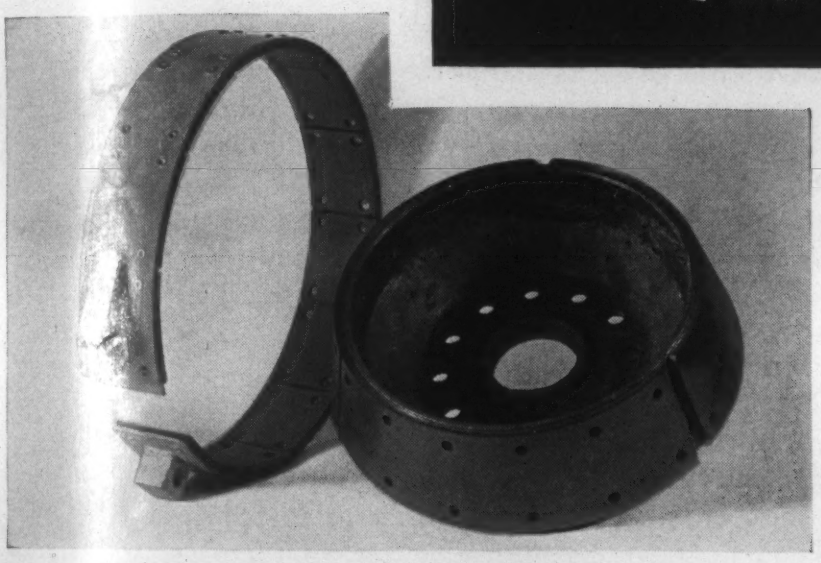
Punch press brake shoes lined with laminated Velvetouch rivet-on facings.



Steering clutch disks for popular make of tractor with facing rings of Velvetouch material welded to opposite sides of each disk.

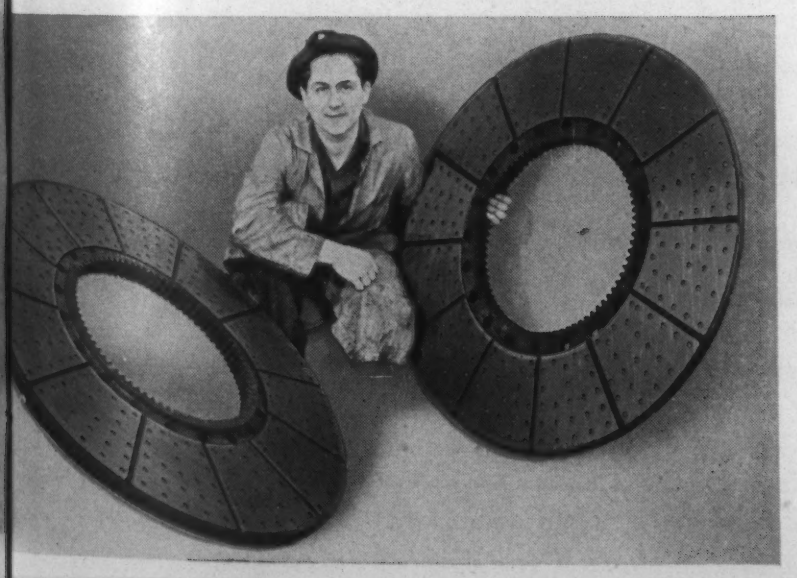


Various laminated Velvetouch disks used in modern airplane brakes.



Cone hub and contracting band for a popular make of earth moving equipment lined with Velvetouch linings.

Punch press assemblies having segmental Velvetouch facings welded to steel carrier plates.



Brake assembly for forming press in which the laminated Velvetouch segments of the assembly are riveted to the carrier.

produce the friction forces vital to their operation and control.

Prominent among the manufacturers of sintered metal friction elements is The S. K. Wellman Co. of Cleveland. The product of this company is largely of the bimetallic or reinforced type, and is marketed under the trade-name "Velvetouch." By the term "bimetallic" or "reinforced" type of construction is meant an element in which a sintered metal facing layer is bonded to a stronger metal backing plate, such as steel. The bond unites the two members so firmly that the strength of the steel plate overcomes any lack of strength in the sintered metal layer. Samuel K. Wellman and his associates pioneered in the development of this highly successful metallurgical product, and the balance of this article is devoted to a review of that development and to a more detailed description of the product and the processes by which it is manufactured.

Some Historical Background

From the historical point of view, it must be recognized that bonded bimetallic sintered metal articles are quite old. In 1885, Canda[1] disclosed a process for sintering a metal bearing lining to a tinned bearing shell. Subsequent to Canda were a number of workers whose efforts were directed to bonding sintered tungsten layers to backing members, to provide contact points, breaker points, and X-ray targets. In the early 1920's, Short[2], Williams and Boegehold[3], and others became active in producing reinforced sintered bearings and similar machine elements. Meanwhile practically nothing had been done about making sintered metal friction facings. Gilson,[4] in 1916 disclosed a copper base composition containing minor amounts of lead, tin and graphite with or without such materials as magnesia, talc, or chalk; and in 1929, Guay[5] disclosed that Gilson's composition could be used as a friction material, and proposed to mechanically attach buttons of this material to opposite faces of a metal disk to make a clutch disk. Somewhat later the General Metals Powder Co. also undertook to commercially exploit the use of sintered metal clutch facings mechanically attached to supporting clutch plates.

A typical 3,000-ton hydraulic press in use in the Wellman plant.

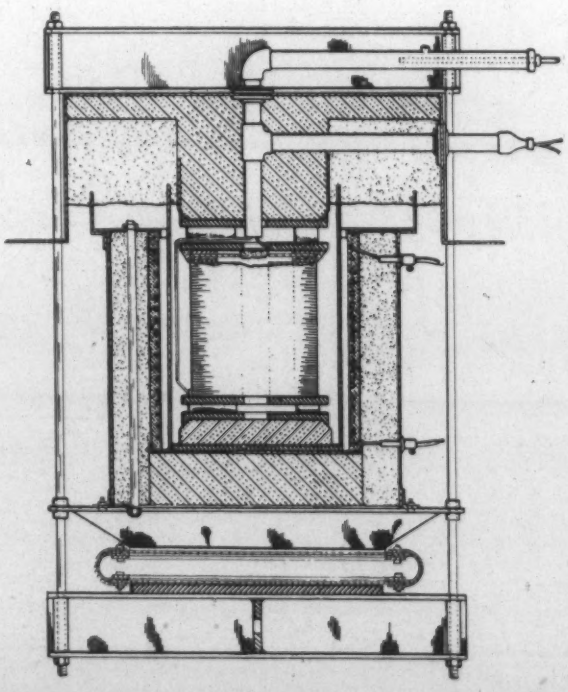
In the early 1930's, S. K. Wellman became interested in the commercial possibilities of sintered metal friction elements, and at the outset appreciated the need for a suitable process for bonding such an element to a reinforcing member. With the aid of the Brush Laboratories Co., he undertook to weld small powdered metal briquettes to a steel strip by pressing the briquette and strip together between the tips of a spot welding machine. This demonstrated that the briquettes could be attached by an autogenous weld, but it was apparent that such a process would be simplified so far as large assemblies are concerned if large plates could be bonded over their surface, and in a single operation, to the steel backing member. Mr. Wellman therefore turned his attention to thermal or furnace processes for making the bond.

Since the briquettes (the compressed powdered metal layers) had to be sintered anyway, it seemed possible that a process could be developed in which the sintering and bonding could be performed in the same operation and in the same furnace. Mr. Wellman was thinking in terms of brake strips and clutch rings, and therefore appreciated that any bond, however produced, should extend continuously throughout the mutual areas of contact between the sintered facing and the reinforcing strip. Furthermore, the bond should be at least as strong as the sintered facing, and should retain its strength at moderately elevated temperatures. This latter requirement operated against the customary tinned or soldered bond used in the bimetallic bearings because Short[6] had taught that such a bond was apt to fail at the temperatures reached under service conditions. Mr. Wellman therefore sought to make a "direct" bond; that is,

one in which there was no interposed layer of weaker metal between the sintered layer and the reinforcing plate.

To this end he undertook to bond the facing briquette to a steel backing by pressing the briquette against the clean surface of the steel plate while suitably heating the assembly in a reducing atmosphere. Some composite assemblies produced in this manner were bonded well enough to have commercial utility, and for a time the method appeared quite promising. However, the product was found to be variable as to the quality of the bond produced, and it became apparent that there was some unknown factor affecting the bonding operation with resultant rather wide variation in the quality of the bond produced.

In the poorly bonded assemblies, notwithstanding the use of care in cleaning the steel backing member, in grinding the steel member to provide a clean exposed surface, and in heating the assembly in a non-oxidizing or reducing atmosphere, evidences of oxidation of the steel backing surface were apparent. As efforts to solve the problem were continued, it was noted that the bonding troubles were greatest in humid weather, and this clue finally led to the discovery and establishment of the fact that the failure to secure good bonds was chiefly due to moisture and other oxidizing vapors or gases that were adsorbed in the porous facing member and driven out into direct contact with the steel backing member when the assembly was heated in the bonding operation.



A diagrammatic cross-sectional view of the sintering furnace showing the arrangement of the stacked disks with the bell-type heating unit in place to apply downward pressure to the stack while heating the work.

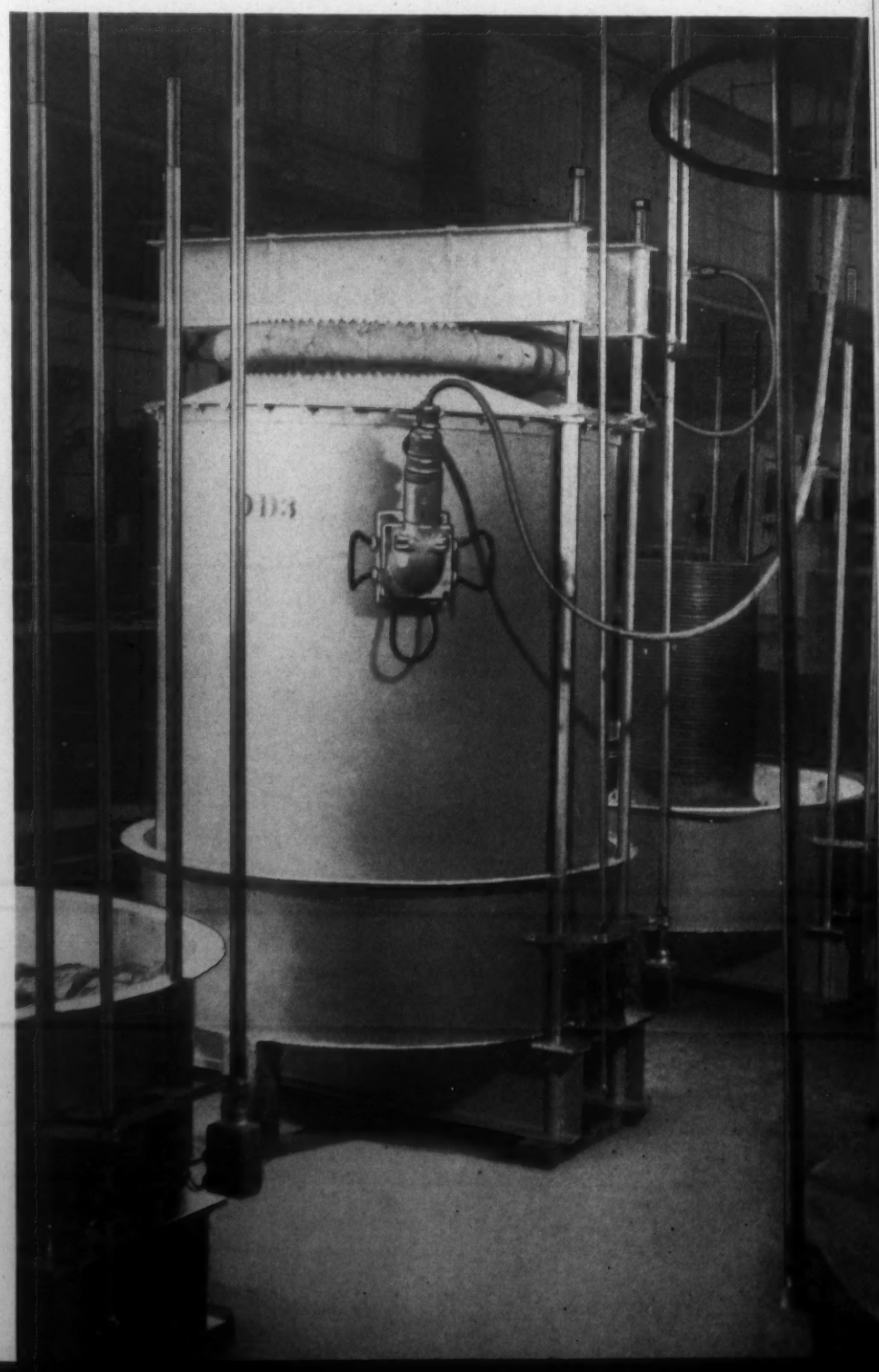
Three Methods Tried

The discovery of the cause of the failure led to the working out of three different methods or procedures for overcoming the difficulty and producing sound bonds.[1] One method involved the principle of fabricating and bonding the briquette to the steel under atmospheric conditions that would prevent adsorption of oxidizing vapors or gases in the porous facing. This method requires controlled air-conditioned factory space.

A second method involves the steps of heating the facing so as to drive out the adsorbed gases and vapors and also effect sintering if the briquette had not previously been sintered, and then preventing access of oxidizing vapors or gases to the facing until it has been assembled on the backing and bonded to it.

In the third method, as in the second, no effort is made to keep the internal pores of the facing free of oxidizing vapors or gases during the whole period of manufacture, but oxidation or corrosion of the

A typical bell-type heating furnace used in sintering and welding the Velvetouch bimetallic assemblies. In the background may be seen a stack of bimetallic disk assemblies arranged on a furnace base in preparation for welding and sintering.



steel backing by such gases or vapors is prevented by applying a thin film of protective metal to the steel surface which is to be bonded to the facing. The film of metal is conveniently applied by electroplating, and may consist of copper, nickel or silver. These several metals function somewhat differently but each appears to withstand the corrosive attack of the gases expelled from the facing without forming oxidation products which interfere with the formation of a sound bond. The protective film may be very thin, and is adequate even when 0.0001 in. or less in thickness.

It is interesting to note that Mr. Wellman and his associate, Dr. C. B. Sawyer of the Brush Laboratories Co., conceived the use of such protective layers at about the same time that Swartz,[8] working independently, conceived the idea of using a protective layer of copper. A curious thing about the Wellman and Sawyer, and Swartz processes is that if the electroplated layer is of the order of thinness noted above, it disappears during the sintering and bonding operation with the result that there is no intermediate layer between the sintered layer and the steel plate of the finished product. In other words, the processes then produce a "direct" bond between the steel of the backing member and the high-melting-point metal of the facings. Of course, if the electroplated layer is of appreciably greater thickness, a distinctive metallographic structure is developed between the sintered layer and the backing member.

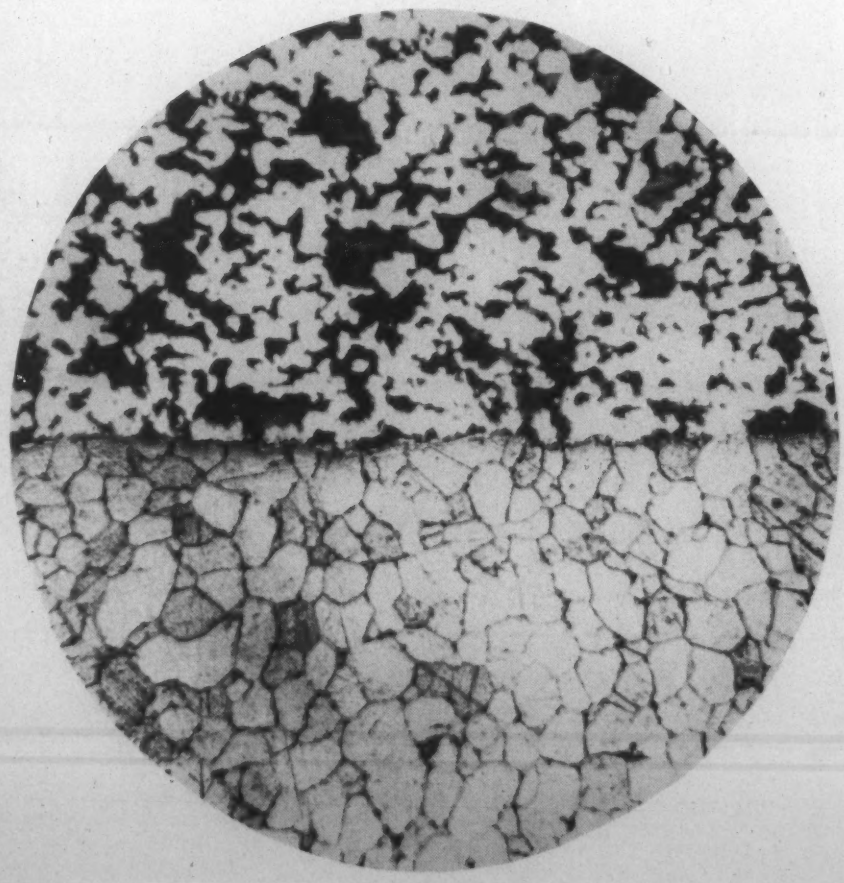
The strength of the bonds so produced has been demonstrated to be greater than that of the sintered metal layer, and it has been found that the strength is retained when the brake or clutch assembly is operated at temperatures as high as 1100 deg. F.

Such in general is the story of the development of this process which is now carried out on a large scale in the Cleveland plant. By the processes now in use in the Wellman plant, many varieties of composition in many shapes for friction clutches, brakes and so on are being made.

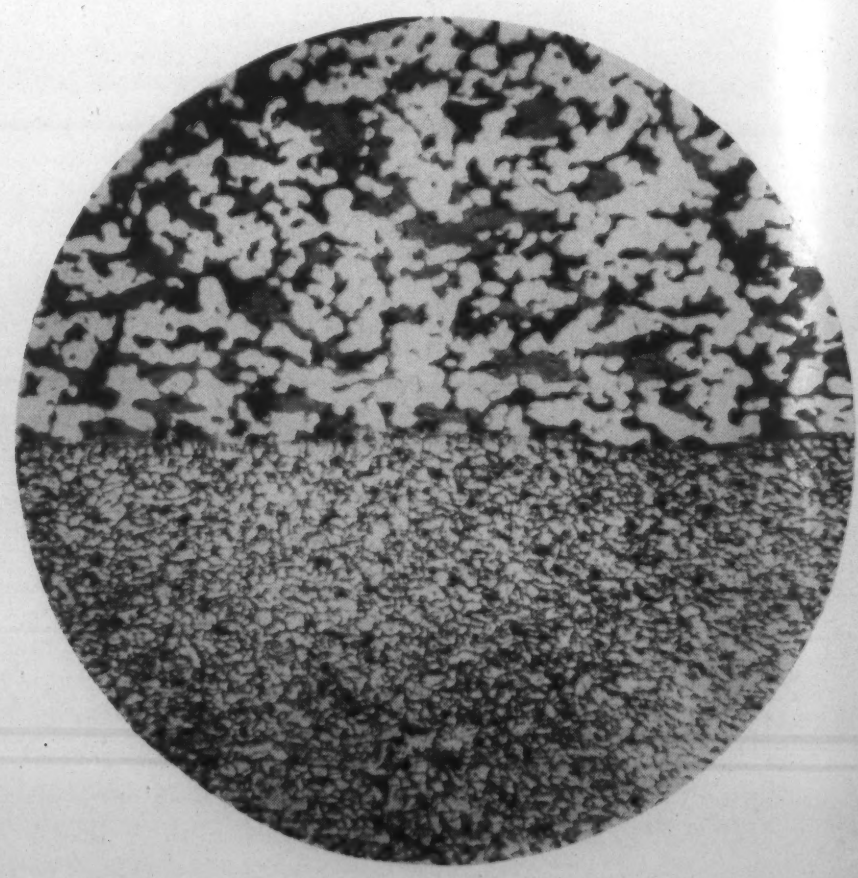
Powdered Metals Used

The powdered metals which enter into these Velvetouch products are copper, lead, tin and iron to which are added in most cases, graphite and silica. Most of these materials are purchased from the producers, though powdered iron is manufactured by a special process[9] in the plant. By means of appropriate mixing apparatus these materials are combined in proportions suitable for the application involved. For example, for clutch and brake disks a satisfactory composition has been found to be 73 Cu, 14 Pb, 7 Sn

Photomicrograph showing a typical bond between an SAE 1010 steel backing member (bottom) and a copper-base sintered-metal friction layer (top); magnification 500 diam.; specimen etched.



Photomicrograph showing a typical bond between an SAE 1035 steel backing member (bottom) and a copper-base sintered-metal friction layer (top); magnification 500 diam.; specimen etched.

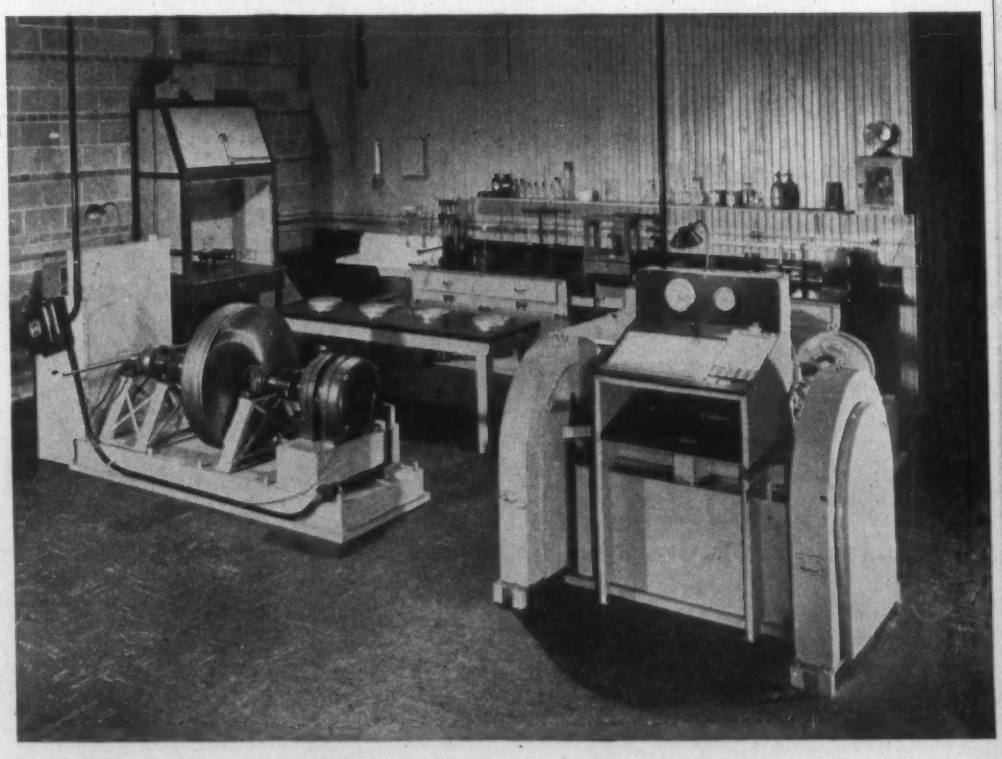


General view of plant laboratory where new materials are constantly being developed.

and 6 per cent graphite; for friction clutches, 70.9 Cu, 10.9 Pb, 6.3 Sn, 7.4 graphite and 4.5 per cent silica, as well as also 62 Cu, 8 Fe, 12 Pb, 7 Sn, 7 graphite and 4 per cent SiO_2. For bearings one suitable composition consists of 79 Cu, 9 Pb, 2 Ni and 10 per cent graphite.[7] A wide variety of specific compositions can be used, however, and through appropriate selection, they provide wide ranges of mechanical and frictional properties.

After the various specified mixtures have been made by careful weighing and mixing, they are transferred to a mold or die adjacent to hydraulic presses. The mold or die conforms to the shape of the briquette desired. By means of a spreading device[10] which prevents stratification and segregation of the coarse and fine, heavy and light components, the mixtures are very evenly spread over the bottom surface of this die or mold. The mold is then put into the hydraulic press and the mixtures are cold-pressed at about 11 tons per sq. in. A typical press is shown on page 846. The briquette so formed is then stripped from the mold in a stripping device[11] and is ready for further processing.

The usual reinforcing plate or backing for the "Velvetouch" products is sheet steel of various compositions—SAE 1010, 1035, X 4130, 18 and 8 stainless, and others—brought into the plant from steel sheet manufacturers. From these sheets are stamped the reinforcing shapes which are used in making the



Close-up view of two different dynamometer testing units.

clutches and brakes. After being stamped out, they are cleaned and then electroplated to prepare them for the bonding operation.

The compressed metal powder briquettes, and the

variously shaped steel reinforcing forms or "cores" are then brought to an assembling place where they are fitted together to form the desired product when bonded. The assemblies are then arranged in stacks on the base of a bell-type sintering furnace, each assembly being separated from adjacent assemblies in the stack by means of separators[7] which prevent them from sticking together. The stacks are enclosed in a suitable iron shell so that an appropriate reducing atmosphere may be maintained around them, and are then subjected to the necessary temperatures under mechanical pressure sufficient to insure firm contact between the parts to be bonded together. Following the heat treatment, the furnace cover is removed and the iron shell then prevents access of air to the assemblies while they are cooling down. When the assemblies are subsequently removed from the furnace, they are cleaned and trimmed, if necessary, and are then ready for shipment. A variety of assemblies produced in the Wellman plant are shown in the attached color pictures.

The Furnaces Used

The sintering furnaces are of unusual design.[12] In general such a furnace comprises a fixed base structure and a removable bell-type top or cover structure. The stacks of assemblies are supported by the base, and are heated externally by means of electrical resistors carried in the removable bell cover. Pressure is applied to the stacks of assemblies through the top wall of the bell cover, and is obtained from an air diaphragm which is mounted on top of the bell cover. The reaction of the diaphragm is taken by an overhead framework connected to the fixed base of the furnace so that inflation of the diaphragm presses the bell cover downwardly to apply pressure on the stacks of assemblies. The picture and drawing on page 847 show the construction of the furnace.

The reducing atmosphere referred to previously is generated within the iron shell which encloses the stack of assemblies by introducing lump charcoal into the shell with the assemblies when the furnace is loaded. The reducing gases so generated are permitted to escape from the furnace through a single gas outlet while the furnace is being heated up to the sintering and bonding temperatures, but as soon as the furnace begins to cool off after the sintering is completed, natural gas is connected to the gas outlet so that as the furnace cools off, the natural gas will flow in and make up for any contraction of the reducing atmosphere due to cooling.

Sintering and bonding is effected at temperatures between about 1350 and 1650 deg. F., depending on the composition of the friction mixture. Pressure is usually applied to the parts being sintered during the entire heating cycle so that the briquettes and electroplated "cores" are held in firm contact all the time until bonding has been accomplished. The equipment of the Wellman company includes a large number of these furnaces.

Structure of the Products

A microphotographic cross-section of the composite assembly is interesting only because of what it shows about the nature of the bond. The sintered network is similar to that shown micrographically by Gilson,[13] but the nature of the union between the steel and the sintered layer is revealing. Two micrographs are reproduced herewith showing the structure of one product made with a core of SAE 1010 steel and of another with a core of SAE 1035.

"Velvetouch" bimetallic friction material was first used in the industrial field as clutch material on heavy punch press equipment in some of the largest automotive stamping plants. Clutch facings of this material have also been successfully used in earth moving equipment for at least 7 years. The material is also being used in agricultural machinery, in trucks, tractors, tanks, machine tools, and airplanes.

Service tests and records have shown that this material has a longer life than ordinary friction materials. Among some of its other advantages may be mentioned its capacity for sustained operation at high temperature, its uniform friction, and its suitability for use where smooth clutch and brake operation and uniform coefficient of friction are necessary.

It is of interest to add that The S. K. Wellman Co. has, in addition to the facilities of the Brush Laboratories Co., a complete technical laboratory of its own devoted to the development and manufacture of sintered metal friction materials and industrial bearing materials. New materials are constantly being studied by testing them on dynamometer equipment which simulates road or service conditions. Metallographic and other inspection equipment is also at hand to aid the development work. The views on page 849 show a portion of the laboratory and its equipment.

In these days of superlative demand for machinery of many types—for airplanes, tanks, trucks and so on—The Wellman company is operating its capacity to the full limit.

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[5] Guay Patent No. 1,700,493 of Jan. 29, 1929.
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[7] Wellman and Sawyer Patent No. 2,178,527 of Oct. 31, 1939.
[8] Swartz Patent No. 2,161,597 of June 6, 1939.
[9] Wellman and Tower Patent No. 2,261,196 of Nov. 4, 1941.
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[11] Wellman Patent No. 2,259,094 of Oct. 14, 1941.
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[13] Gilson, E. G., "Genelite—A New Bearing Material," *Machinery*, Vol. 29, 1922, pp. 123-124.

Induction Heating in War Production

by FRANK T. CHESNUT

Secretary, Ajax Electrothermic Corp., Trenton, N. J.

A broad picture of the extent to which inductive heating is a factor in the Defense Program is presented by the author. The many applications of induction heating—melting, forging, brazing, surface hardening and so on—are discussed. The furnaces and processes described are developments of the Ajax Electrothermic Corp., (division of The Ajax Metal Company), under patents of the late Edwin F. Northrup. The article was delivered as a paper before the fall meeting of the American Society of Mechanical Engineers early in October.—The Editors.

INDUCTION HEATING, inaugurated during World War I, finds itself an indispensable tool in the waging of World War II. While many mechanical innovations such as war planes and tanks made their appearance for the first time during the earlier conflict, World War I must be considered a war of men, whereas the present conflict is much more a war of machines and production.

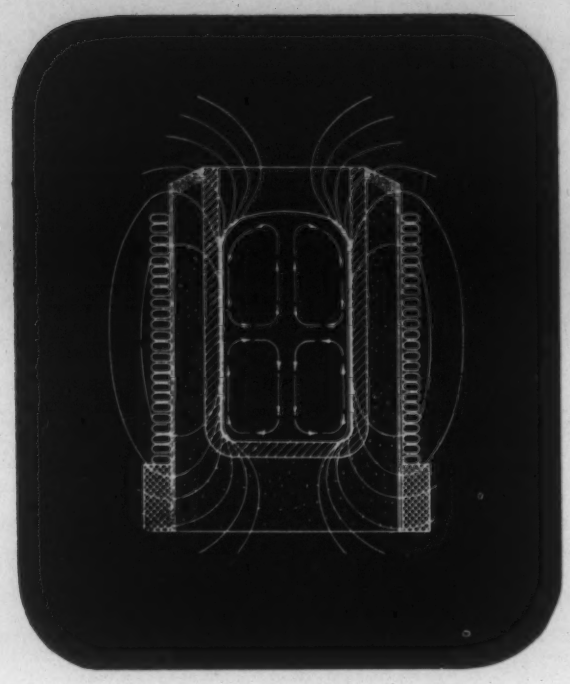
The part man power is playing in the present war, however important on the battlefield, is more important than ever before in the shops and factories behind the lines. Airplanes of greater speed, carrying power or maneuverability; tanks with rugged, trouble-free engines; guns with more fire power; projectiles with higher velocities, penetration or shattering effect, and machines, for one reason or another more effective than those of the opponent, are urgently sought. In all of these things, induction heating has been a contributing factor of no small degree.

Centrifugally Cast Guns

Almost since the advent of the modern field piece gun barrels have been fashioned from ingots, forged, heat treated and machined to shape. The larger guns are still made this way. Since about 1930, however, the centrifugal casting method has been supplanting the old method, especially for certain classes of ordnance.

By the centrifugal casting method, the ingredients which make up the steel for the barrel are melted in an induction furnace where the melting and alloying is fast and where melting losses are low. The metal is then carried in the furnace as a ladle and poured into a horizontally rotating mold. The ro-

Many modern guns are made by the centrifugal casting process from induction melted steel. (Courtesy: U. S. Army Signal Corps.)



Cross-section of Ajax-Northrup induction furnace, showing magnetic field and stirring action when melting a charge.

tation of the mold is continued until the casting has become solidified. The gun barrel thus formed is removed from the casting machine after which it is heat treated, rough machined, expanded by a cold working process, and finish machined.

In the casting operation, several items are noteworthy. First, because of the centrifugal forces involved, the barrel is formed not as a solid ingot requiring an expensive hollow forging or machining operation but one already having a hole through its center. Second, any slag particles or impurities which may have found their way into the mold, being lighter than the steel of which the barrel is made, are floated to the bore, by pressure of the metal against the mold, where they are removed when the barrel is machined.

It may be said conservatively that by the centrifugal casting method a better gun can be made at much less cost and in very much less time than by methods heretofore employed.

Projectiles

Induction heating is particularly adapted for forming, brazing and hardening operations in making projectiles. For such work, the main advantages are speed and uniformity of heating, the ability to control the heat to specific patterns, freedom from scale, the relatively small floor space required, an improvement in working conditions for the operator and the fact that the equipment as a whole can be turned to peace time operations without loss of investment.

In forging a 75-mm. shell, the operations are about

Forging a 75-mm. shell from a bar heater by induction. (Courtesy: The Iron Age)

as follows: Long bars of SAE X1340 steel of 2⅜ in. diameter are delivered to the shears where they are cut into lengths, each sufficient to form two shells. To avoid brittle fracture on shearing, the bars are sometimes preheated to about 200 deg. F. Representative discs are cut from each end, ground and etched in 50 per cent by volume of hydrochloric acid to check the stock for pipes and seams. The blanks are then fed one end at a time into induction heating furnaces where they are heated to 2350 deg. F. for forging.

There are five induction heaters for each forge machine and with an individual heating time of 2 mins. and 20 secs., the furnaces are capable of supplying a heated blank to the forge machine every 28 secs. Each heater is adapted to draw 80 kw. at 400 volts, and at a supply frequency of 2000 cycles. While a frequency of 1000 cycles would be sufficient for the work, the higher frequency was selected because of its more ready applicability to automotive work on smaller diameter pieces at a later date. The furnaces are adapted to heat the bar uniformly over the part to be forged from end to end and from surface to center.

During the heating cycle, power is set and timing is automatic. The power factor, though varying somewhat on each individual heater, is constant on the supply generator. The power required for heating is about 0.22 kw. hr. per lb. of metal heated.

After heating, the bars are forged by the displacement piercing method in upsetting type forging machines using multiple cavity dies. Because of the rapid heating, only a soft scale forms on the billet and the wear on the dies is appreciably less than with bars heated by other methods. Although the first cost of the induction heating equipment is high, the unit heating cost per shell is lower than with other methods due to the short time cycle, longer die life and less time out for repairs and die changing. In addition, there is no heat loss or operator discomfort around the induction furnaces.

After the hot forging operation, the shell is trimmed from the blank, rough machined, cold nosed in a 350-ton press, finish machined, banded, reinforced with a welded butt plate, inspected, marked, painted and shipped to the filling station.

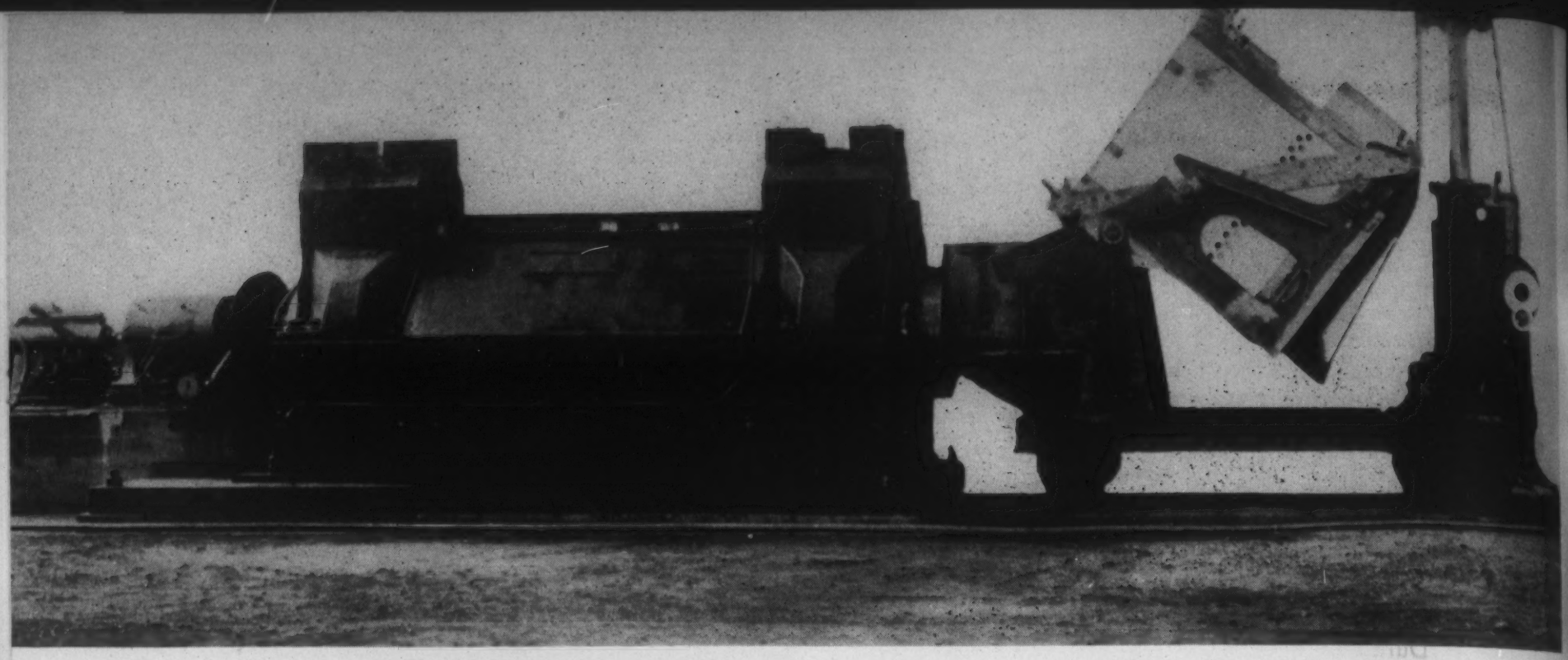
Nosing of Large Shells and Bombs

An operation generally comparable to the forging of shells is the nosing of larger shells and bombs. The same advantages exist for these jobs but usually the heating coils are arranged with graduated or spaced turns to heat the blanks more at the end than farther down in the piece. This is done to prevent petticoating or bulging of remote parts under the pressure of the dies. Some shells are nosed in a single stroke press while others are shaped by a swedging operation. Bombs are made from seamless tube and are spun to shape.

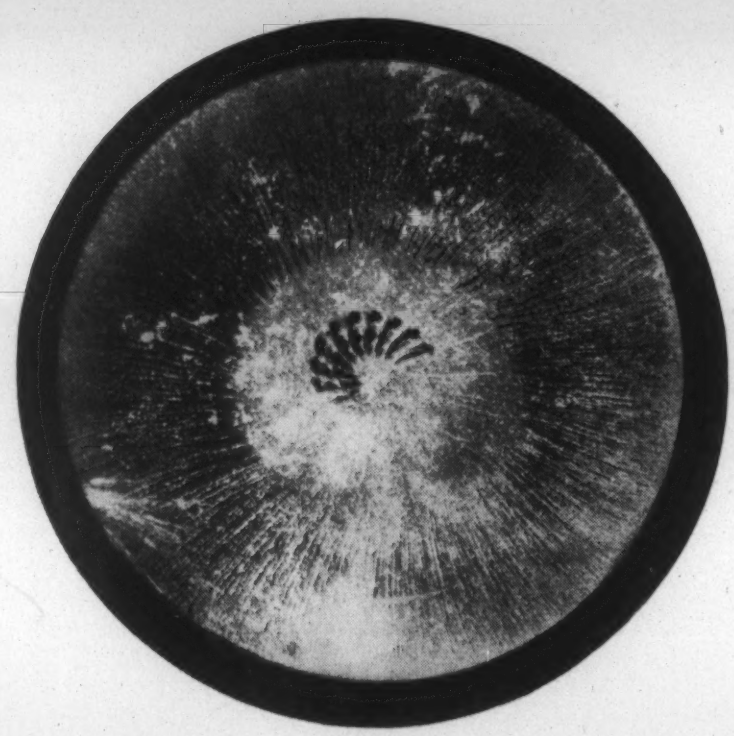
High alloy steel ingots being poured from a high frequency induction furnace. (Courtesy: Carpenter Steel Co.)

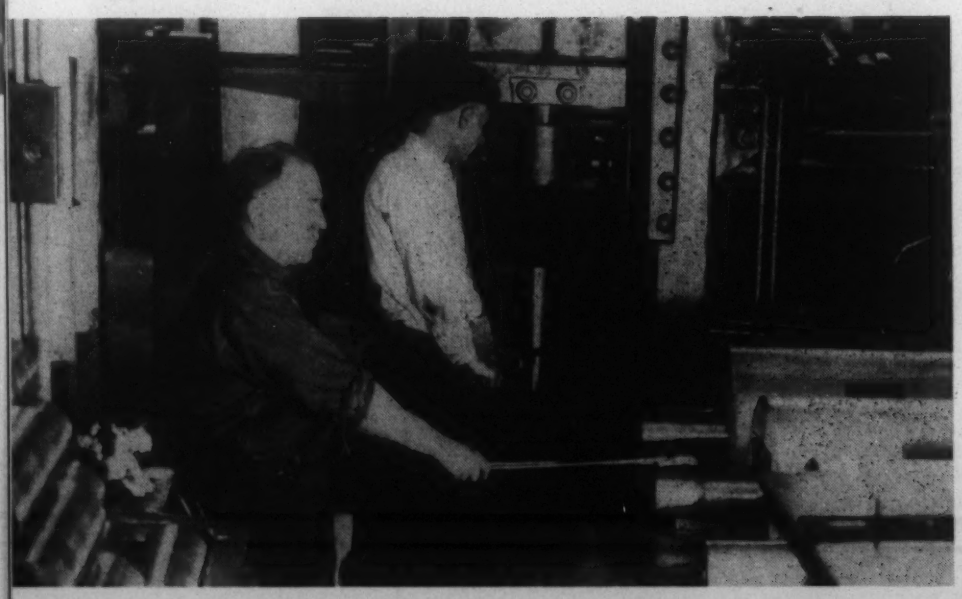
One producer in making a 5-in. anti-aircraft shell from a 5-in. diameter, 9/16 in. wall steel blank, heats 1½ in. at the end to 1850 deg. F. and tapers the heat off to a visible temperature 6 in. back in the piece. The voltage across the coil is 400 and the frequency 960 cycles. Heating time at 75 kw. is 1½ mins. per shell but a group of three furnaces supplies a blank to the forging machine at the rate of one every 30 secs. A single stroke, 250-ton hydraulic press is used for the nosing operation.

The same producer, in making a 100-lb. bomb from 8-in. diameter 3/16 in. wall steel tubing, heats the nose end to 2250 deg. F. for a distance of 6 ins. and tapers the heat off to a visible temperature in a total of 11 ins. For the tail end, 5 ins. is heated to 2150 deg. F. and a total of 9 ins. is heated to visibility. After heating, the respective ends are spun to shape. The heating coils are arranged with graded turns and operate at 400 volts and 960 cycles.



Casting a gun centrifugally with the induction furnace in pouring position. (Courtesy: U. S. Ordnance)





Heating steel blanks in induction furnaces for nosing 155-mm. shells. (Courtesy: U. S. Ordnance)

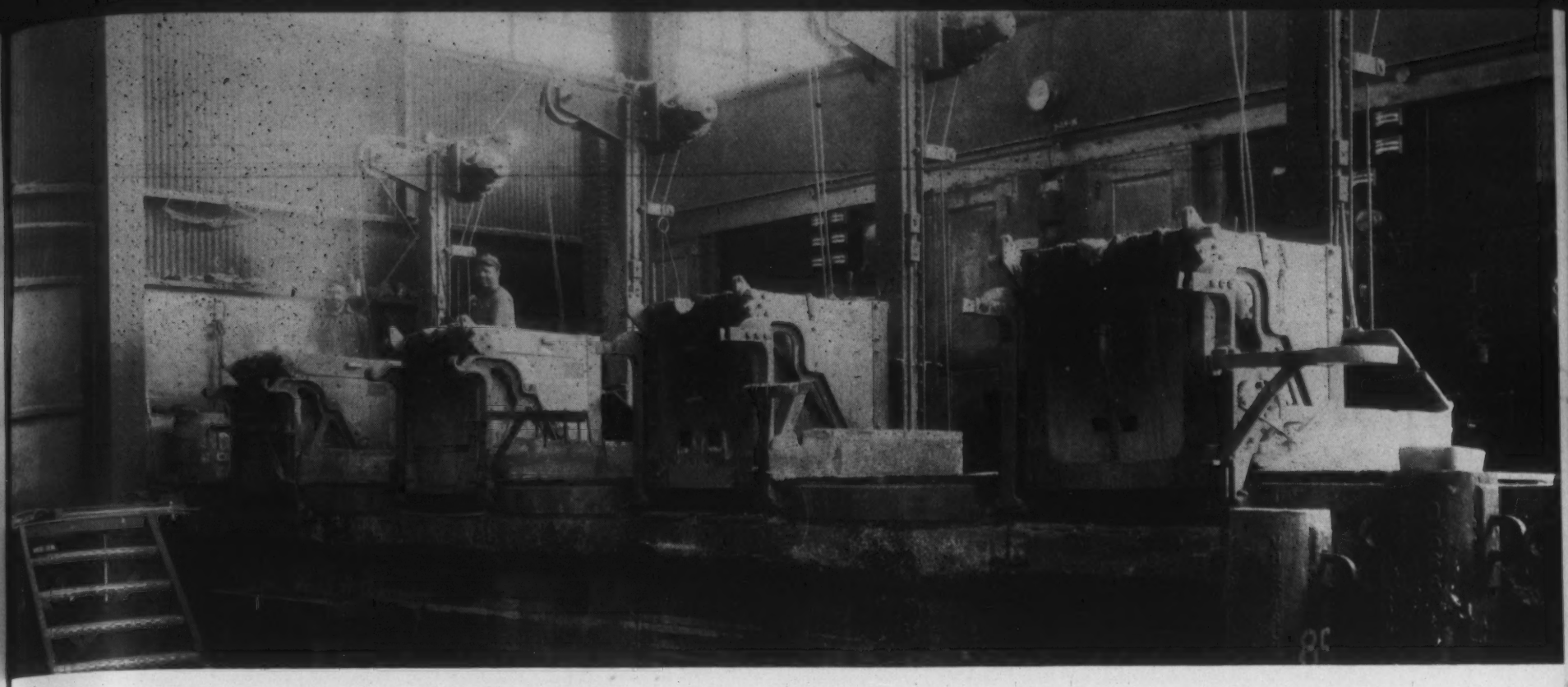
Heating time is 1½ mins. for each end but 100 kw. are applied to the nose while only 75 kw. are used for the tails.

Adapters for chemical shells, formerly welded, are now brazed and the heat is supplied by induction. The surfaces are prepared, a ring of brazing compound is placed in position, the assembly is inductively heated and the parts are forced together. Heat is localized at the point of use and a seal is made in 74 secs. with but 10 kw. of 12,000 cycle power. With the previous welding process, the time cycle was 4 mins. and the seal never could be considered sure. By the induction brazing methods, the seal is 100 per cent sure.

Some armor piercing shells are point hardened by an induction process. Because of the tendency of high frequency current to travel at the surface of conductors and because a great amount of energy can be crowded by induction into a small localized area, it is possible to heat the point and end surface of a projectile to the quenching temperature without affecting the substructure. The heating and quenching operations require only a matter of seconds and handling can be entirely automatic giving a large output with a small equipment outlay. One 6 kw., 40,000 cycle, laboratory equipment is capable of hardening a 37-mm. shell point every 15 secs. with a daily output of over 4,000 shells.

Surface Hardening

The surface hardening described for armor piercing shells finds a multiplicity of applications in engines and parts for airplanes, tanks, submarines, boats, armored cars and the like. By an induction heating and hardening process, the surface of a crankshaft bearing, for instance, can be so hardened, without affecting the toughness of the steel below the surface, that the bearing will last ten times longer before



Induction melting furnaces are standard equipment for making high-grade alloy steels. (Courtesy: Carpenter Steel Co.)

attention than it would without such treatment. While the frequency, power and time of heating vary widely for different articles or size of pieces treated, a bearing of 1½ ins. diameter and length can be surface hardened to a depth of 3/32 in. with 150 kw. of 2000 cycle current in less than 10 secs.

The process is equally applicable to internal and external surfaces and finds use for such applications as crankshaft and camshaft hardening, hardening of shafts, rolls, pins, gears, valve stems and seats, the internal surfaces of engine cylinders, the integrally formed bearing races for wheel hubs and the like. In each case, and for hundreds of other applications dealing directly or indirectly with the military effort, the heating of the surface is so fast that the desired hardening operation can be achieved before the substructure can be affected by conducted heat.

Besides surface hardening, induction heating is used for zone hardening of gun and motor parts and plays a prominent role in many brazing and forging operations in connection with such parts. Induction heating is used frequently to expand a part later to be shrunk onto another piece and sometimes to heat such a part to remove it from the base piece.

The nickel-chromium wire used for spark plugs and the tungsten contact points used with practically all gas motors are produced in induction furnaces. Similarly, all of the Alnico magnet steel used in the radio and meter parts is exclusively an induction furnace product. Much of the flexible shafting connecting the meters and the flexible tubing used to protect control wires is inductively annealed before use and many parts of the meters themselves have inductively brazed parts.

Nearly all of the external airplane bearings are of a lead-bearing copper alloy made in the induction furnace because it is about the only furnace in which no segregation takes place. In the radio and control apparatus, all of the vacuum tubes are inductively heated during sealing to drive off occluded gas from the metal parts.

Miscellaneous Applications

No attempt has been made to discuss or even to list all of the applications of induction heating or melting in the war effort but a few applications not directly concerned with guns, shells and motorized equipment are deserving of mention.

Induction melting furnaces are used in substantially all of the navy yards, arsenals and private manufacturing plants where special alloys and castings are made. These furnaces, because of their inherent mixing characteristics and fast melting, find favor wherever the steel or alloy to be melted is of a fussy or exact analysis, where it has expensive ingredients, or where speed is essential. Stainless steels and corrosion resisting alloys are commonly melted in these furnaces, as are most of the high speed steels and carbides used for cutting tools. Many valves and fittings of both bronze and steel, and especially high pressure bronze castings for naval torpedoes, are made from induction furnace metal.

In addition to the production units, many industrial and governmental laboratories use induction furnaces for experimental study of war time emergency problems. Induction furnaces operating from normal frequency current are used for low temperature heating applications such as for the heating of autoclaves or chemical vats for hydrogenation processes where the presence of a flame or spark might be disastrous.

High temperature induction furnaces, operating at temperatures exceeding 4000 deg. F., are used for the graphitization of carbon bodies and for the fabrication of tungsten carbide and high melting point metals for tools, dies and the like and, experimentally at least, new methods are in operation for the recovery of magnesium metal from the base ores.

Some Open-Hearth Problems–1941

Some of the papers and articles on open-hearth practice which were made public early this year are reviewed and discussed by the author. This part of the article resembles a correlated abstract but is in scope considerably beyond this.

There is also a thorough discussion on Slag Metal Relations. In the author's opinion, the work on this subject "represents one of the most important fronts of advancing knowledge during 1940."

The article is appraised as of great value to serious students.—The Editors.

By FRANK G. NORRIS

Open-Hearth Metallurgist, Wheeling Steel Corp., Steubenville, Ohio

New occasions teach new duties; Time makes ancient good uncouth; They must upward still, and onward, who would keep abreast of Truth.

—James Russell Lowell.

THE ASCENT UP THE HILL of knowledge is made by a series of steps with an intermediate plateau rather than by a constantly sloping incline. It seems reasonable to read into Lowell's "upward" the flights of stairs, sometimes they appear to be winding stairs, and into the "onward" reference to the plateau which teachers recognize as characteristic of the learning process. What applies to the learning of the individual may well apply to the contributions to a general field of learning. Although, "we see dimly in the Present what is small and what is great," there is reason to believe that within the last year fundamental knowledge of steel making has taken a step or two up from a plateau and can be expected in the near future to make a series of further advances.

In any article based chiefly on evidence which has been previously published, the author may well repeat the words of Mark Antony: "I tell you that which you yourselves do know." Without apologizing further for the limitations of "a plain blunt man" it is proposed to take stock of some of the accepted ideas expressed during and immediately previous to last year's Open Hearth Meeting, to note the contributions made during the year; at least, to point out and perhaps partially to reconcile the apparent contradictions between the old and the new, and to use the work of the past and the needs of the present to gain a preview of the probable course of development in the immediate future. The subjects which have been chosen for discussion are not necessarily those of greatest importance, but those of immediate interest as evidenced by one or more recent contributions.

Bessemer Process

It may seem out of place that the first topic in a paper with the words open-hearth in the title should be a consideration of another important process of steel manufacture. Nearly half of the total production of Bessemer steel is used as blown metal in the open-hearth charge. The other half seems destined to become an increasingly important competitor of open-hearth steel in various applications. So, from the standpoint of his own raw material and of competition with his own product, the open-hearth man has a two fold interest in the recent progress of the Bessemer process.

An equally important reason for interest lies in the chemical similarity of the two processes. When writing a chemical equation of a reaction in an aqueous solution the type of beaker or test-tube is not specified. Similarly fundamental knowledge of reactions in a ferrous solution is equally applicable to metal in a furnace, a vessel, or even in the small pool under a welding torch. The results of much research that has been conducted for application in the open-hearth can be used in these other fields. With prospects of increasing research in the Bessemer process, the alert open-hearth operator will consider the possible application of the results to his conditions.

Several papers on the Bessemer process will not be discussed in detail because they have already been reviewed in the January METALS AND ALLOYS.[1] The mere fact of so many papers on this one process, which as Graham says has been neglected by technologists in the past several decades, is worthy of

mention, and is indicative of probable increased interest in Bessemer steel.

Application To Operating Problems

Two of the papers illustrate the benefits of the application of recently developed methods to operating problems. One of these methods is the use of statistical analysis in discerning the effect of variations in the process on the quality and properties of the product. It may have been possible to have developed flame control without the aid of statistical methods, but the development could not have made so much progress so quickly without this aid.

The other method is the treatment of molten metal with slag. There are apparently three conditions for such treatment. In the Aston process, steel is poured into liquid slag which is intentionally retained in the steel. In the Perrin process the slag is intended to separate from the steel, and in the Yocom process solid slag is added to the stream of liquid steel. The fact that Yocom found liquid slag less desirable suggests that there are many details of the treatment of steel with slag yet to be explored. It seems reasonable to expect, especially in the face of impending restrictions in the use of aluminum, that deoxidation of open-hearth steel by the use of a slag with a high solubility for FeO will be considered.

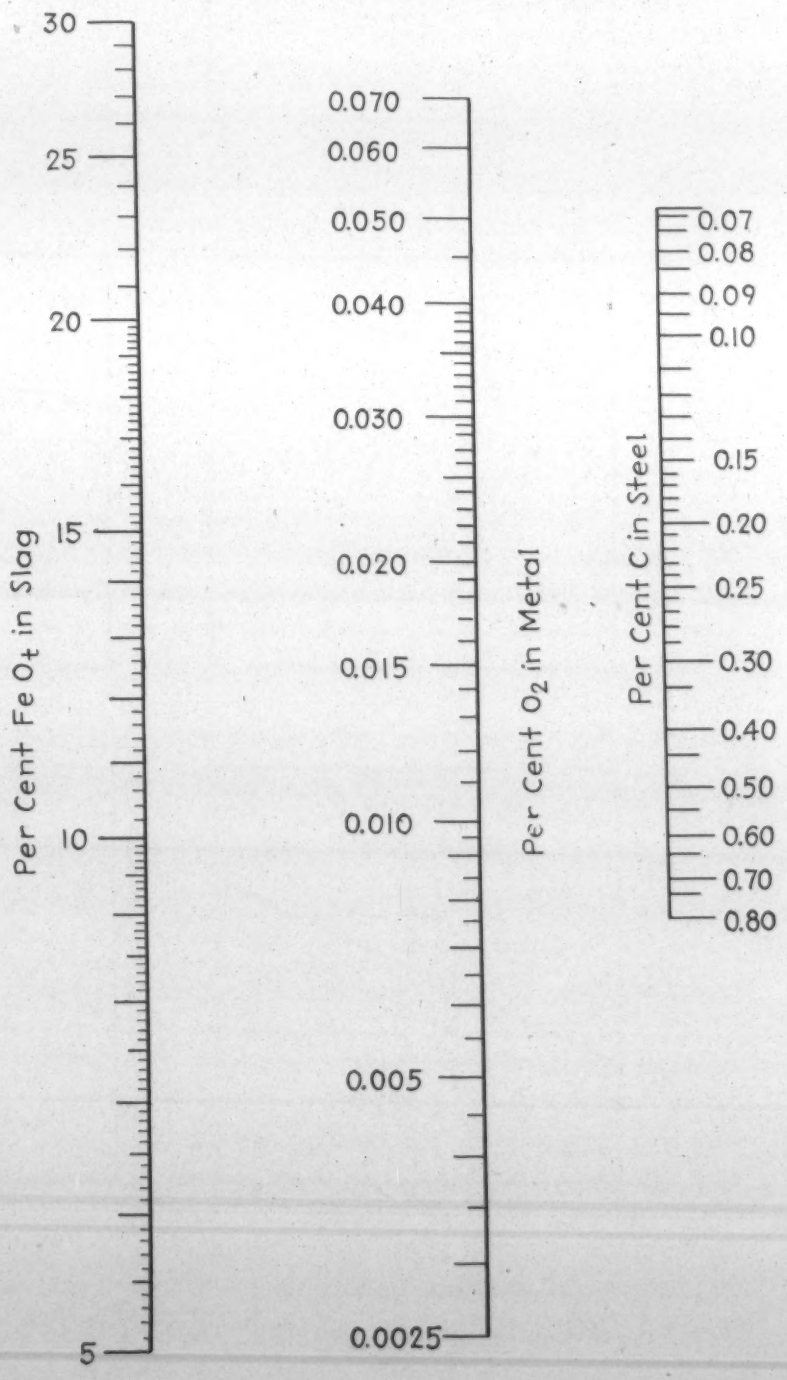
Three papers at the February, 1941, A.I.M.E. meeting[2] indicate the continued interest and increasing technical assistance that the Bessemer process is receiving. This increase in interest has been accompanied by an increase in Bessemer tonnage which last year was of the order of 7 million tons of ingots and 7 million tons of blown metal for duplexing. The amount of this increase that is the result of an abnormal demand bringing marginal units into operation cannot now be estimated. There is every indication that developments in the near future can be expected in the layout of plant, construction of the vessel, raw materials, pneumatic system and control instruments. The photocell method of control has the advantages of being rapid, quantitative, recorded, and furnishing definite reference points for interpretation. Several of the figures of Work's paper indicate the smoothing of points to a linear relation when the influence of extraneous incidental variables is removed simply by the force of large numbers.

If a group of some 15,000 is required to insure the random effect of all variation except that due to the factors under study, the failure to find perfect relations in groups of 100 or 500 does not indicate that the relation or trend does not exist. In fact, the relation between nitrogen and blowing time for 500 blows while definite is not nearly as close to a line as in case of relations studied in the group of 15,000. One possibility is that the relation may be just as good but is not so perfectly disclosed in the smaller group. Such results suggest the possibility that in many fields only a systematic study of information already being gathered and recorded (sometimes at considerable effort and expense) is required to disclose relations that perhaps are now overlooked.

Temperature Measurement

One paper published during the year[3] states, "the quick immersion thermocouple has solved the problem of accurate determination of liquid steel temperatures in practice." In this country the problem is not yet solved. There is a possible choice of at least two couples each with its own usefulness and limitations. There is also the possibility of various combinations of recording instruments used with the Oseland tube. As far as is known there has been no substantial change in the method described by E. D. Martin and by M. J. Bradley at the 1939 open-hearth meeting. The possibilities of the photocell pyrometer

Fig. 1. Relation of oxygen to carbon and FeO_T.



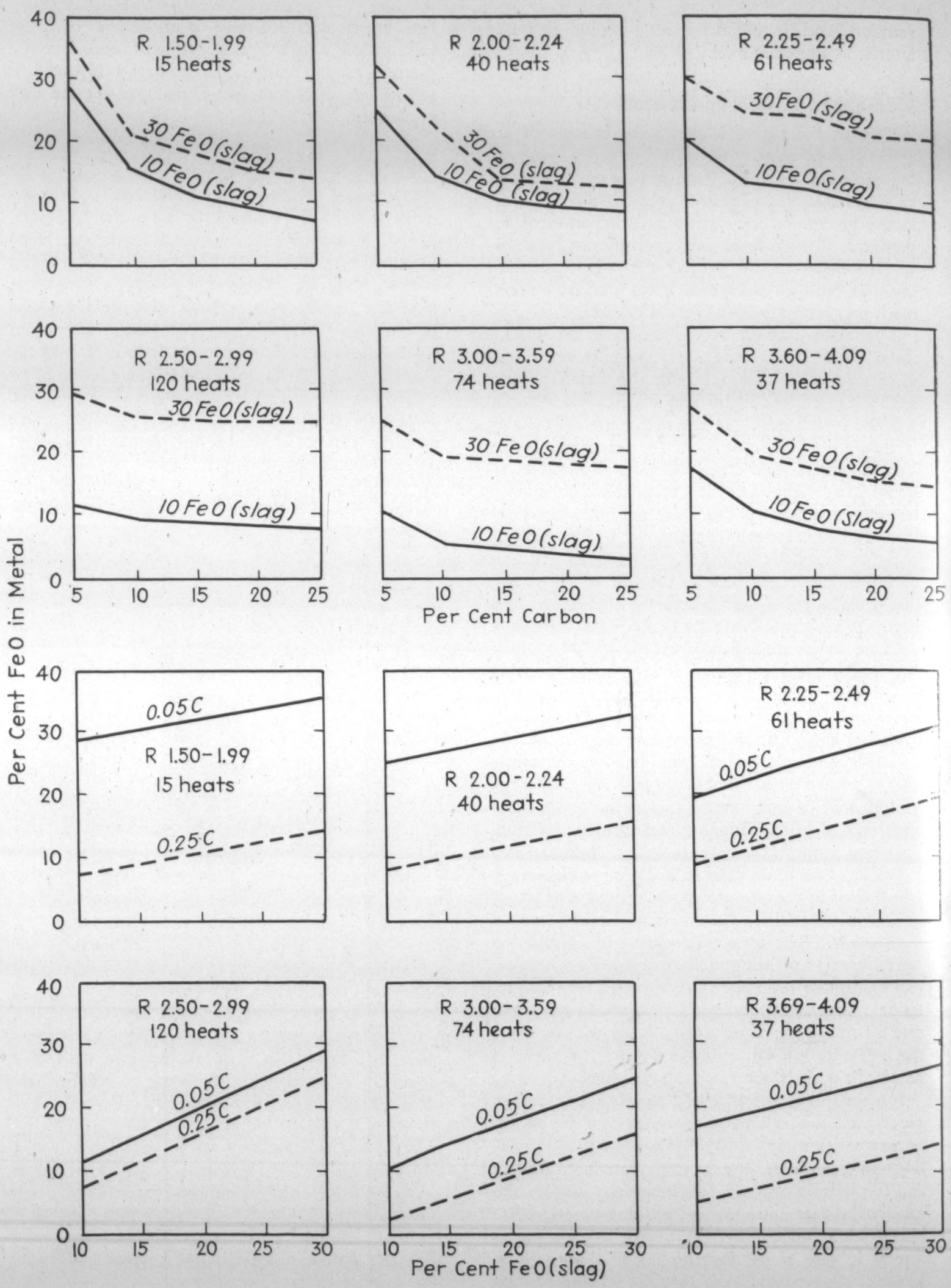


Fig. 2. Effect of carbon, basicity and FeO_T on oxygen.

that has been recently described[4] for measuring temperatures in open-hearth furnaces are being watched with interest.

Although the method of temperature measurement is not specifically mentioned, much of the consistency found in Larsen's[21] results can be attributed to reliable temperature data. Probably temperature is the most important factor concerning which there is the least information, or restated, the ratio of amount of reliable data to importance of effect is lower for temperature than for any open-hearth variable. It is likely that this need will be the object of further work and important developments.

Solidification of Ingots

A heat balance based on temperature measurements during solidification was published in Russia.[5] A somewhat similar study[6] confirms existing theoretical formulae and shows that the greatest difference between theory and practice is at positions in the mold near the inner face. This difference is attributed to the effect of the air-gap between the ingot and the mold.

In the past attention has been given to the effect of casting temperature and speed, and the size and shape of the ingot. A recent paper[7] adds a new factor—"turbulence"—and indicates its effect on the structure and properties. This concept appears to offer an improved explanation of observed differences in the results of various methods of casting.

Hydrogen

Several papers dealing with the determination and the effects of hydrogen in liquid and solid steel indicates the importance of this element. This is an extremely light element so that amounts which may have considerable effect may be overlooked as insignificant when reported by weight per cent. If all of the elements are reported as mols per 100 grams, the importance of hydrogen is more easily understood. A more practical treatment is simply to recognize the fact that very small percentages of hydrogen have important effects.

Lepp[8] has used Chipman's[9] data to calculate the co-existence of oxygen and hydrogen in molten iron. It happens that the possible concentration of iron oxide is limited to such a low value by its solubility that this calculation does not appear to indicate a practical way to eliminate excess hydrogen absorbed by the metal. A recent German paper[10] introduces at least one new technique and several new ideas in the study of hydrogen. The new technique is the method of sampling to prevent loss of hydrogen during solidification and cooling. In other words, the method is designed to determine the hydrogen in the bath as distinguished from that in the solid sample taken from the bath in the usual manner. The situation is somewhat like the comparison between carbon and oxygen in a killed or rimmed sample over which there has been long and bitter argument, arising chiefly from failure to agree, not on the interpretation of the results, but on which results were of greater interest to the operator dealing with the liquid and to the user of steel solidified from this liquid. So although hydrogen in the bath does not all remain in the solid, information regarding it may be useful if properly interpreted.

One new idea not generally accepted by open-hearth men is hydrogen as a constituent of slag. The hydrogen content of the slag depends on the furnace atmosphere and temperature and affects the hydrogen absorption of the steel which for a given slag is independent of temperature. Of lesser importance regarding hydrogen absorption is the manganese which roughly is parallel to the hydrogen. The hydrogen content of the steel is expressed as the product of a constant which depends on temperature, of the hydrogen in the slag and of the square root of the MnO/Mn ratio. Hydrogen is reported as independent of the boiling of the bath. This result is at variance with some suggested methods for eliminating hydrogen. The hydrogen content does not change during pouring or standing in the ladle. A comprehensive consideration of the sources of hydrogen in practical operation has been published in Swedish.[11]

Two recent papers[12, 13] indicate the practical importance of hydrogen. Although one of these deals chiefly with malleable cast iron, the possible sources of hydrogen and the method of analysis are of general interest. Moisture, rusty scrap and high hydrogen fuels are mentioned. The need for a dependable method for the analysis of hydrogen that will distinguish with certainty between hydrogen and water in iron was brought out in the discussion. It is beyond the purpose of the present article to mention the most recent contribution[13] to the knowledge of the effects of hydrogen further than to state that this study indicates that hydrogen embrittlement is associated with a mosaic nature of metal crystals and, therefore, provides new viewpoints regarding the crystalline sub-structure of steel.

Slag Metal Relations

Two German papers published during the year are of interest in regard to slag studies. One[14] of these reports the relations between appearance of slag cakes, micrographs of slag sections, lime/silica ratio and viscosity. Another interesting development[15] on which more work is anticipated is the rapid microscopic method for determining slag constituents that is particularly suited for control purposes which was reported at the February 1941 A.I.M.E. meeting. The other German paper[16] indicates that the manganese constant for a complex slag system (i.e. slag containing several types of

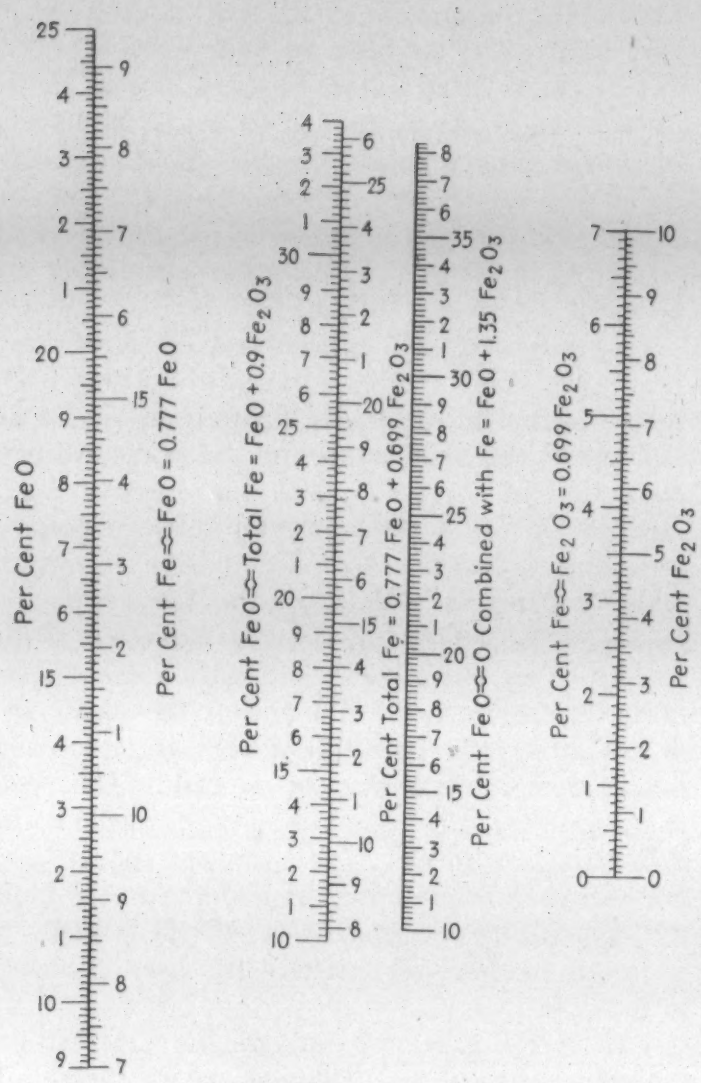


Fig. 3. Alignment chart for calculating relations between oxides of iron in open-hearth slags.

anions) is the sum of several functions involving the concentration of the separate anions and of the manganese constants derived from simpler slag systems.

Before discussing further work done in this country on slag metal relations, the background work dealing only with slag systems independently of the metal should be mentioned.[17] Comparison of these results with those of Fetters shows the reducing effect of the iron bath. For optimum reducibility—all other factors being neglected—the definite ratio of 2 CaO to SiO_2 must be maintained. Fig. 2 of Fetters and Chipman (A.I.M.E. Tech. Pub. 1316) may be considered to confirm this condition of optimum reducibility in the special case when the reducing agent is liquid iron. For a given FeO content the maximum oxygen in the metal is found with those slags having the CaO/SiO_2 ratio at or near 2. This important composition is at a value of CaO/SiO_2—1.86 when the concentrations are expressed in weight per cent.

A similar study[18] of these slag systems was published in this country in the Fall of 1939. These papers will not be discussed in detail because they are not as recent and are more generally available than the paper by Hay and White. The phase relations in the system CaO-ferric oxide-silica have recently been reported[19] for compositions from 15 to 65 per cent CaO and up to 65 per cent Fe_2O_3. The amount of ferrous oxide developed by heating the preparation wrapped in platinum foil at about the liquidus temperature for 15 min. and quenched in air was found to increase with increase of temperature and higher silica content. The largest percentage of ferrous oxide found after this treatment was about 3 per cent which was not believed to cause a significant error in the results. The application of this investigation is of greater interest in the production of sulphate resisting cements than in a consideration of slags which seldom contain such high percentages of Fe_2O_3. There is general agreement that neither Fe_2O_3 nor FeO can exist alone in equilibrium slags containing lime or silica.

An excellent example of a study of plant data containing a cross section of the practice from several open-hearth shops was read[20] at the open-hearth meeting a year ago. This paper may be considered the most recent knowledge of slag metal relations in the open-hearth, and of calculating and presenting the results. More recent papers cover relations not in the open-hearth. Some of the findings are recorded in such condensed form that it is profitable to review them so that they can be more readily visualized. Other points in this paper not emphasized at last year's meeting are important in retrospect because of new ideas introduced by related studies during the year.

Estimating Oxygen in the Bath

The methods of estimating the oxygen content of the bath are given in Table I and Figs. 2 and 3. Fig. 2 is in essential agreement with Fig. 4 of Fetters and Chipman. Fig. 3 based on their equations (Table 8) is presented for two reasons. It is extremely difficult, if not impossible, for most people to visualize relations such as are expressed in this set of equations. The second reason is that the misunderstanding that has arisen concerning the effects of carbon justifies clarification of the results.

At last year's open-hearth meeting, Chipman explained the relative importance of carbon by saying:

> If you are going to consider all of those, residual manganese, MnO, and basicity, then you can come up to a pretty good approximation of the degree of oxidation without even knowing what the carbon is. But even when all of those are considered independently of carbon, the correlation is not so good as it is with the carbon content alone.

The data of Fetters and Chipman's Table 8 (as plotted in our Fig. 3) show that the relative influence of FeO_T and C on the FeO of the metal can not be discussed independently of the slag basicity. Each square in Fig. 3 represents a different range of

basicity. The six squares at the top are plotted to show the effect of increasing carbon at two extreme values of FeO. The six squares at the bottom contain the same relation replotted to show the effect of increasing FeO at two extreme values of carbon. With acid slag the effect of carbon is large and that of FeO is small. With increasing basicity (to R = 2.55-2.90) the effect of carbon becomes less (shown by narrowing of the band in the first four diagrams at the bottom of the page). In the last two ranges of basicity the effect of carbon increased but more slowly so that, in the range 3.60-4.09 variation from 0.05 to 0.25, C has about the same effect as in the range R = 2.25-2.49.

The effect of FeO is shown either by the width of the band in the top diagrams or by the slope of the lines of constant carbon in the bottom diagrams. Its effect is less regular than that of carbon but in general it increases from the acid stage to a maximum in the range R = 2.50-2.99 and then decreases.

The relative effect of carbon is greater than that of FeO (each varying between the extremes of the diagrams) in the two most acid groups. They are about of equal effect in the group R = 2.25-2.49 and 3.60-4.09 and in the two commonest groups (containing 194 out of the 347 slags) R = 2.50-2.99 and 3.00 to 3.59 variation in carbon has very much less influence than variation in FeO. At the same FeO the change from 0.10 to 0.25 per cent C makes scarcely any effect on the oxidation of the bath. In this basicity range carbon could almost be neglected. In a shop or grade consistently in the bascity range R = 2.00-2.24 the carbon alone not only gives more information than the FeO alone, but contains practically all the information possible considering both FeO and carbon.

This diagram has been explained in detail because of the importance of the relation and to show why a superficial consideration results in a discussion resembling that of the blind men describing an elephant.

Table I.—Five Methods for Estimation of the Iron Oxide Content of the Metal.

(From A.I.M.E. Technical Publication 1164; Fetters and Chipman)

1. From C alone:

	Carbon Per Cent	FeO_M Per Cent	
	0.05	0.298	
$C \times FeO_M = 0.0124 + 0.050\ (C)$	0.10	0.174	Standard
	0.15	0.133	Deviation
Equation 1—Table 6.	0.20	0.112	19%
	0.25	0.110	

2. From FeO alone: (Good only below 0.12 C)

$FeO_M = FeO_T/107$

The factor 107 is at 0.06 C on Fig. 4.

FeO_T	FeO_M	
10.0	0.093	
15.0	0.140	Standard
20.0	0.187	Deviation
25.0	0.234	26%
30.0	0.280	

3. From FeO and C

Data of Fig. 4.

C Per Cent	.05	.10	.15	.20	.25
FeO_T Per Cent / FeO_T/FeO_M	104	117	132	146	160
10	.096	.085	.076	.068	.062
15	.144	.128	*.114*	*.103*	*.094*
20	.192	*.171*	.152	.137	.125
25	.240	.214	.190	.171	.156
30	*.288*	.256	.228	.205	.187

Values in italics are near those by Method 1

4. From FeO-C-Basicity

Data of Table 8—see Fig. 3.

Good from 0.02 to 0.31 per cent C

$$\text{Basicity "R"} = \frac{CaO}{SiO_2 + .634\ P_2O_5}$$

Standard Deviation = 15 per cent

5. From MnO and Mn

Restricted to below 0.31 C

$FeO_M = 252\ MnO/Mn$

Standard Deviation = 31 per cent

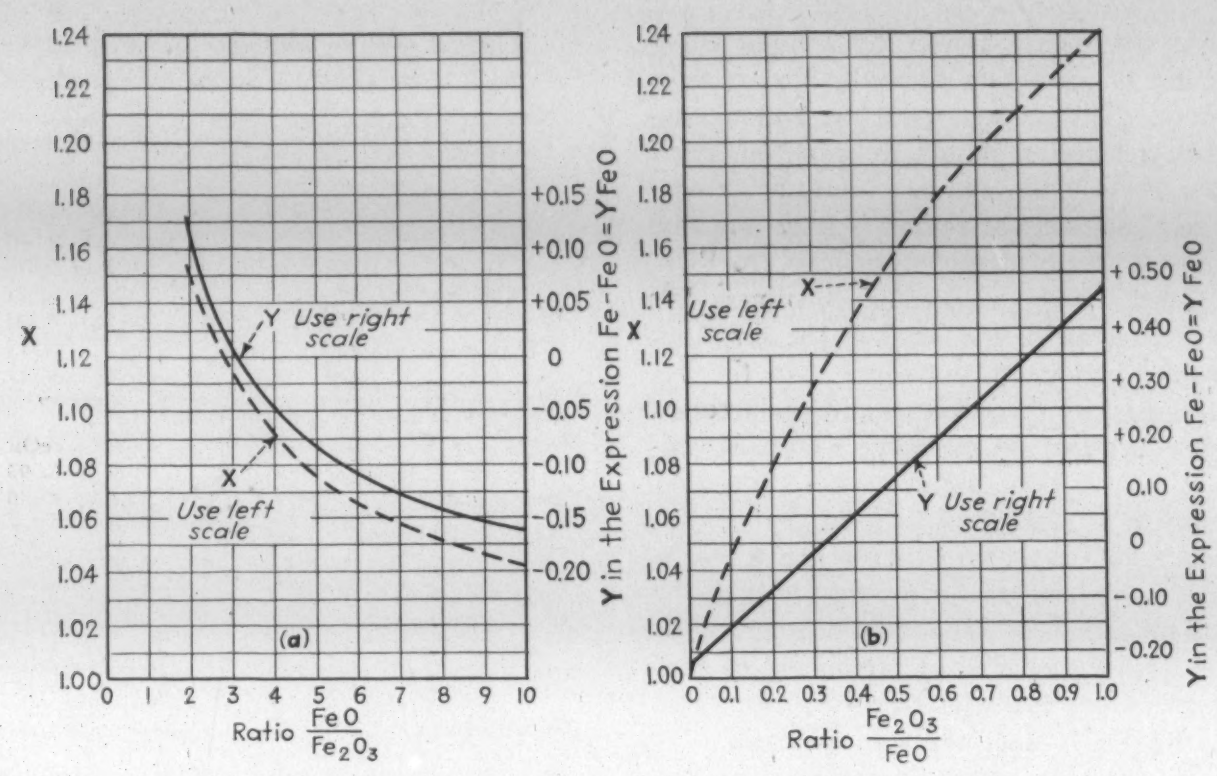
Three Important Papers

There are three important papers[21] dealing with slag metal relations. There is no necessity for abstracting these papers or duplicating discussion of the original paper. It may be well, however, to bring together in one place for comparison some teachings of these three papers.

Fetters and Jette both worked in practical absence

Table II.—Slag Calculations.

	Weight Percent										Fetters		Jette				Larsen		
Slag	Fe	FeO	Fe_2O_3	P_2O_5	SiO_2	CaO	MgO	MnO	S	$\frac{CaO}{SiO_2}$	FeO_x m.f.	x	Tot. Mols	$(FeO)_t$ m.f.	R	$_aFeO$	Tot. Mols	FeO_e m.f.	B
1. Reference	25	25.0	8	1.65	13.0	39.0	6.0	7.2	0.15	3.0	.2842	1.11	1.575	.3164	1.485	.2595	.9642	.5168	2.98
2. High silica	25	25.0	8	1.65	14.5	39.0	5.3	6.4	0.15	2.7	.2848	1.11	1.572	.3169	1.342	.2736	.9153	.5445	2.68
3. Low lime	25	25.0	8	1.65	11.7	35.1	8.4	10.0	0.15	3.0	.2826	1.11	1.584	.3148	1.473	.2594	.9667	.5155	2.96
4. Low lime	25	25.0	8	1.65	13.0	35.1	7.8	9.3	0.15	2.7	.2832	1.11	1.581	.3151	1.335	.2728	.9259	.5382	2.67
5. High lime	25	25.0	8	1.65	14.0	42.0	4.2	5.0	0.15	3.0	.2850	1.11	1.571	.3202	1.488	.2624	.9606	.5188	3.02
6. High lime	25	25.0	8	1.65	13.0	42.0	4.6	5.6	0.15	3.23	.2848	1.11	1.572	.3169	1.602	.2503	.9953	.5006	3.24
7. Low MgO	25	25.0	8	1.65	13.3	40.0	4.5	7.4	0.15	2.99	.2862	1.11	1.564	.3185	1.480	.2618	.9774	.5098	3.00
8. High MgO	25	25.0	8	1.65	12.4	37.0	9.0	6.8	0.15	2.99	.2800	1.11	1.599	.3119	1.470	.2572	.9381	.5312	3.02
9. Low MnO	25	25.0	8	1.65	13.7	41.2	6.3	4.0	0.15	3.01	.2817	1.11	1.589	.3135	1.496	.2563	9415	.5292	3.00
10. High MnO	25	25.0	8	1.65	12.2	36.4	5.6	11.0	0.15	2.98	.2862	1.11	1.564	.3185	1.449	.2568	.9864	5052	2.91
11. Low FeO	25	23.2	10	1.65	12.9	38.9	6.0	7.2	0.15	3.02	.2868	1.14	1.561	.3273	1.494	.2678	.9790	.5217	3.01
12. High FeO	25	27.7	5	1.65	13.1	39.2	6.0	7.2	0.15	2.99	.2788	1.07	1.606	.2985	1.479	.2455	.9538	.5031	2.99
13. Low Fe	15	15.0	4.8	1.65	15.6	46.9	7.2	8.7	0.15	3.01	.1628	1.11	1.650	.1812	1.508	.1475	.8640	.3464	3.02
14. High Fe	30	30.0	9.6	1.65	11.7	35.1	5.4	6.4	0.15	3.00	.3523	1.11	1.525	.3923	1.450	.3258	1.0035	.5965	2.94



Figs. 4a and 4b. Relation between expressions related to Fe_2O_3 in slag. These are the same relation except that in one case the abscissa is the reciprocal of the other.

(below 0.01%) of carbon. Fetters used synthetic slags of 5 components—FeO, Fe_2O_3, SiO_2, CaO, MgO. Jette worked with slags containing all the constituents of open-hearth slag. He considers the essential constituents to be the five named above plus MnO, P_2O_5 and S.

Before proceeding very far with any of these papers it is necessary to understand mol fractions. Mol fraction is a means of expressing concentration that is used when the slag is considered as a solution in the application of the laws of physical chemistry. The practical obstacle to its more general adoption (aside from the tedium of the computation) lies in the necessity for a complete slag analysis in order to calculate the mol fraction of any one component. In other words, the mol fraction method takes into account the effect of changes not only of the constituent in question, but of all the rest of the slag.

Jette interprets the square root of the basicity as the reciprocal of the activity coefficient of FeO. The casual reader is almost certain to be confused by failing to note the difference in the treatment of activity of FeO in Jette's and in Fetters's papers. There are two distinctions. Fetters reports the activity whereas Jette uses the function of basicity as the activity coefficient. The other distinction is in the definition of a standard state. Jette chooses a standard state such that the activity equals the $(FeO)_{t.o}$ when $R = 1$. Fetters defines a standard state in which pure iron oxide (not pure FeO) is in equilibrium with iron at the temperature in question. The activity of FeO in any slag is obtained by dividing the oxygen content of the equilibrium metal by the saturation value which at 1600 deg. is 0.23.

Referring to the term FeO_x there are two ways of finding the numerical value of "*x*." They are both equivalent and of course give the same answer. Using Fetters's "short cut" method, "*x*" is the ratio of mols of O to Fe in the iron oxides of the slag. The mols of either Fe or oxygen in FeO is the per cent of FeO divided by 71.84. The mols of Fe in Fe_2O_3 is the per cent Fe_2O_3 divided by half of 159.7; the mols of O is the per cent Fe_2O_3 divided by one third of 159.7. The other way of finding "*x*" is by using factors that are already familiar; *x* is FeO + 1.35 Fe_2O_3 divided by FeO + 0.9 Fe_2O_3.

An alignment chart has been prepared (Fig. 3) for ease in making these conversions. If the per cent FeO and Fe_2O_3 are known, these are located on the two outside scales and connected by a ruler, preferably having a transparent edge. From this one setting the values needed in the above calculations can be read immediately from the two middle scales.

The term "*x*" in FeO_x is a means of showing the relation between FeO and Fe_2O_3 in the slag or a means of expressing the amount of Fe_2O_3. Other functions that also vary with Fe_2O_3 are the ratio of FeO/Fe_2O_3 (or its reciprocal is sometimes used) and the difference between the total iron and the FeO. The term "*x*" bears a fixed relation to the FeO/Fe_2O_3 ratio, the only difference being in the sensitivity which is to say in the size of the change in "*x*" for a given change in Fe_2O_3. As the Fe_2O_3 changes from zero to a value equal to the FeO the ratio changes from ∞ to 1, the reciprocal ratio from 0 to 1 and "*x*" from 1 to 1.24. The difference between total iron and

FeO depends on both the FeO and on the total iron. At zero Fe_2O_3 the difference is equal to —0.223 FeO; at Fe_2O_3 equal to the FeO the difference is equal to +0.476 FeO. This suggests that no Fe_2O_3 is lower at high FeO values than at low FeO values, which seems to carry a concept which is not disclosed by the ratio. The relation between these three functions is shown in Table 3 and Figs. 4a and b. In the range of values common in open-hearth slags (0.0 to 0.6) "y" is a linear function of the ratio $\frac{Fe_2O_3}{FeO}$. The term "y" is defined by the equation: Fe — FeO = yFeO.

Larsen shows that the calculated equilibrium FeO in the metal is much more closely correlated to the FeO in the metal by analysis (r = 0.88) than is the total iron in the slag (r = 0.71). How much of the improvement is due to the change in expressing concentration and how much is due to taking account of variation in temperature is not known. The calculated value is very much higher than the observed value, being a little over 2.25 times as great at an observed value of 0.30 per cent FeO and from 3 to 5 times as much at an observed value of 0.10 FeO.

This is another way of saying that metal high in FeO, although still far away, is closer to the equilibrium value than is low FeO metal. This difference may be caused partly by the lower carbon at the higher FeO.

Table III.—Relation of "x" to Oxides of Iron.

FeO, Per Cent	Fe_2O_3, Per Cent	$\frac{FeO}{Fe_2O_3}$	Fe-FeO	"x"
15	1.0	15.0	—2.65	1.03
15	2.0	7.5	—1.95	1.05
15	3.0	5.0	—1.25	1.08
15	4.0	3.75	—0.55	1.10
15	5.0	3.00	+0.15	1.12
15	6.0	2.5	+0.85	1.13
15	7.0	2.14	1.55	1.14
20	5.0	4.0	—1.00	1.09
20	6.7	3.0	+0.2	1.12
20	10.0	2.0	+2.5	1.15
17	2.6	6.54	—2.00	1.06
16	3.7	4.33	—1.00	1.09
15	4.8	3.12	0.00	1.11
14	5.9	2.37	+1.00	1.14
13	7.0	1.86	+2.00	1.16

Table IV.—Index of Symbols.

Symbol	Reference or A. I. M. E. Tech. Pub. No.	Definition
$[FeO]_M$	1164	Total oxygen of metal taken by bomb sample calculated as FeO
(FeO)	1164	Weight per cent ferrous oxide in slag
$(FeO)_{Total}$	1164	Total iron in slag calculated to FeO or (FeO) + 0.9 (Fe_2O_3)
FeO_t	1316	
FeO	1316 Figs. 1, 2, 3, 5, 7, 8	
FeO	1316 Fig. 11	Mol fraction of ferrous oxide
FeO_e	1319	FeO + 3 Fe_2O_3 concentrations in mols/100 gms. or mol fraction of FeO_e
$(FeO)_{t.o}$	1321	$(FeO)_s$ + 3$(Fe_2O_3)_s$ concentrations in mol fractions
^aFeO	1321	$FeO_{t.o}$ $R^{-1/2}$
FeO_x	1316	The iron oxide of the equilibrium slag $\frac{\text{wt. \% total Fe}}{56}$ or this term divided by total mols
x (the above subscript)	1316	$\frac{\text{mols O}}{\text{mols Fe}} = \frac{FeO + 1.35\ Fe_2O_3}{FeO + 0.9\ Fe_2O_3}$
y	Present paper	$\frac{Fe - FeO}{FeO}$
R	1164, 1321	$\frac{CaO}{SiO_2 + 0.634\ P_2O_5}$ wt. % concentrations; $\frac{(CaO)_s}{2(SiO_2)_s + 3(P_2O_5)_s}$ mol fraction concentrations
B	1319	$\frac{CaO - 4(P_2O_5)}{SiO_2}$ concentrations in mols per 100 grams
$R^{-1/2}$	1321	Activity coefficient of iron oxide in the slag

Calculations For Typical Slags

Several typical slag compositions (Table 2) have been selected chiefly to show the effect of normal variations of the slag composition on the mol fraction of FeO at constant weight percentage of FeO and Fe_2O_3. Slags 11 and 12 have the same total iron as the first 10, but different proportions of Fe_2O_3. The last two slags have different total iron.

The calculations are carried to an extreme number of decimal places in order to bring out the effect of changes in composition that make scarcely any difference in the usual three-figure calculations. Each reader can look over these figures and decide for himself if the differences given by the mol fraction method justify the expense of a complete slag analysis and the trouble of the calculation. Over very wide differences in composition, mol fractions may be necessary for accurate estimations. Within the normal variations usually found in the open-hearth, the ordinary weight per cent will many times be as accurate as is required by the application to be made of the results.

For this range of composition Larsen's basicity follows the ordinary lime-silica ratio very closely though of course changes in phosphorus would change this relation.

Comparison of slags 13 and 14 show the influence of the various methods of calculation. The ratio of Fe or FeO using weight per cent is 2. The ratio is more than 2 using FeO_x, $(FeO)_{t.o}$, and Jette's activity. Using Larsen's value FeO_e the ratio between the two slags is considerably less than 2. This dif-

ference is of course due chiefly to the difference in estimating the total mols. This observation leads to the statement that the heart of the mol fraction calculation is in the assumptions used in figuring total mols. Without explaining and possibly defending these assumptions the use of mol fractions is a possible source of confusion.

Slag Control

Slag control is considered a more general term than iron oxide control. Whether the purpose of a given procedure is control of basicity or of iron oxide may be a matter of definition of objective, but when one is fixed, definite bounds are established for the other. There is less general agreement on what is meant by the term than there is on the necessity for a system of slag control because although a man may not be very proud of the one he uses and may be reluctant to discuss it or to show it to a stranger, everybody has one and finds it absolutely essential, and for each one his own is best because he can't use the other fellow's.

In itself slag is not a product, but a waste material. Although only a means to an end, and ultimately despised and discarded, a good slag is an indication of a healthy condition and a lack of it is a sign (if not indeed the cause) of a sick heat. One that is the result of artificial treatment may relieve the immediate situation, but is not generally considered as satisfactory as one that comes naturally. Little that is new can be added to the subject of Slag Control so soon after Herty's able and comprehensive presentation in the Howe Memorial Lecture in 1940. The other recent discussion of slag control is part of Larsen's paper[21] in which he distinguishes between

1. The essential or fundamental factors:
   Bath temperature,
   Oreing rate,
   Charge composition,
   Slag basicity.

and

2. The secondary or resultant factors:
   Iron oxide,
   Slag viscosity,
   Bath depth,
   Speed of working.

The slag basicity is regarded as an independent variable which can be controlled entirely with regard to operating convenience and economy and to the required sulphur and phosphorus. The importance of temperature, carbon, lime charge, and rate of oreing was recognized by the open-hearth operator before information on FeO was even available, much less understood. Larsen's paper is considered timely lest the limelight of current interest in FeO should cause us temporarily to forget the fundamentals he has emphasized.

It is the humble hope of the author that even such a meagre effort as the present article will contribute in a small way to an appreciation of the grandeur referred to by the ancient Greek philosopher, Aristotle, in the description of the true spirit of science which is engraved on the home of the National Academy of Sciences in Washington:

> Search for truth is in one way hard and in another way easy, for it is evident that no one can master it fully nor miss it wholly, but each adds a little to our knowledge of Nature, and from all the facts assembled there arises a certain grandeur.

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Calcium in Calcium-Lead Alloys

A method is described by the authors for estimating calcium in lead which consists in casting a test ingot in a prescribed manner and comparing its surface appearance with the surface appearance of standards. Calcium content can be determined by inspection.

The ability of an experienced workman to pick out, by eye, tiny differences between different lots of the raw materials that he handles is likely to be pooh-poohed by an inexperienced technical man. Here's an interesting case where, when suitable precautions are taken to make conditions reproducible, the eye is quicker than the spectroscope.

The horse-sense of the scientists who adopt this visual method, is delightful.—The Editors.

by EARLE E. SCHUMACHER AND G. M. BOUTON

Bell Telephone Laboratories, New York

IN THE MANUFACTURE of lead-calcium sheath it is desirable to control the calcium content to 0.028 ± 0.005 per cent in order to obtain the most desirable combination of properties. Since calcium is a very active element chemically, special manufacturing procedures were developed to minimize the contact of molten lead-calcium alloy with the air. Despite the improved techniques, some calcium is always lost and must be replaced. Before this can be accomplished satisfactorily, obviously, the calcium content of the alloy must be determined.

Conventional chemical procedures are accurate but not entirely satisfactory for plant control use because they are time consuming and too costly. The best of the chemical methods introduces a lag of at least 2 hrs. in melting kettle control. Quantitative spectrographic analysis methods were carefully tested, and while they showed some advantage over conventional analyses, they were still unduly time consuming.

Need of a Suitable Method

With the ever increasing interest in lead-calcium alloys for cable sheath, storage-battery grids, and other applications, it became desirable that a rapid, reliable and not too costly method be developed for determining their calcium content. In approaching the problem, several methods of attack involving physical, chemical, or electrical properties suggested themselves. A few of the methods investigated were:

1. Observations of the rate of oxidation or tarnish of freshly cut surfaces using a variety of atmospheres and temperatures.
2. Thermal EMF measurements against pure lead.
3. Measurements of hardness or strength of samples after various heat treatments.
4. Measurements of electrode potentials in various solutions.
5. Use of various metallographic techniques.
6. Observation of recrystallization tendencies after the samples had been deformed.

Unfortunately, none of these methods proved adequate. Either the properties involved were insuffi-

Fig 1. Surface appearance of test ingots of chemical lead-calcium alloys cast in atmosphere containing 0.02 per cent CO_2 and having 50 per cent relative humidity. The dark areas are very bright when viewed with directly reflected light. Approximately full size. The calcium percentages from left to right in the 5 samples or ingots are 0.021, 0.024, 0.026, 0.028 and 0.030.

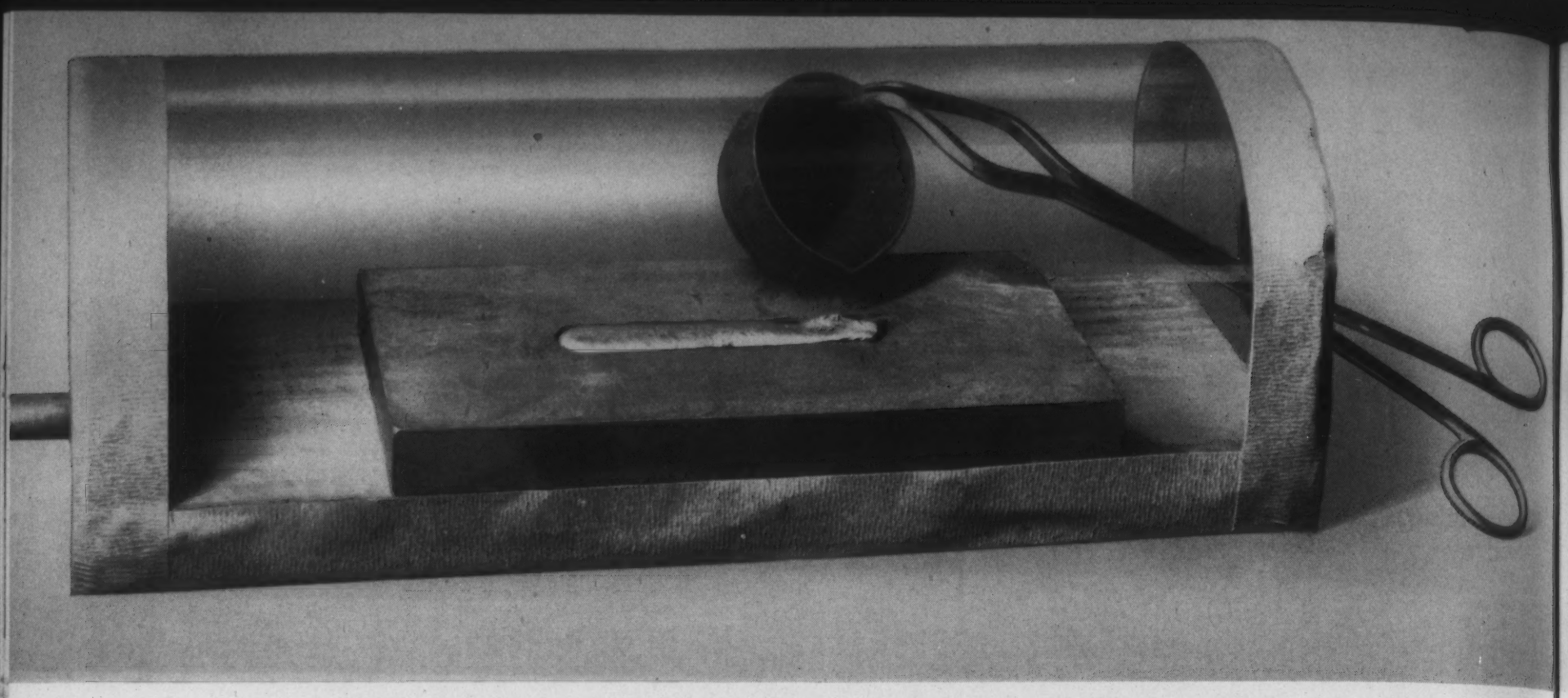


Fig. 2. Apparatus used in casting lead-calcium ingots under controlled atmospheres.

ciently sensitive to changes in calcium content, or other factors masked the effect of calcium.

Clue to a New Method

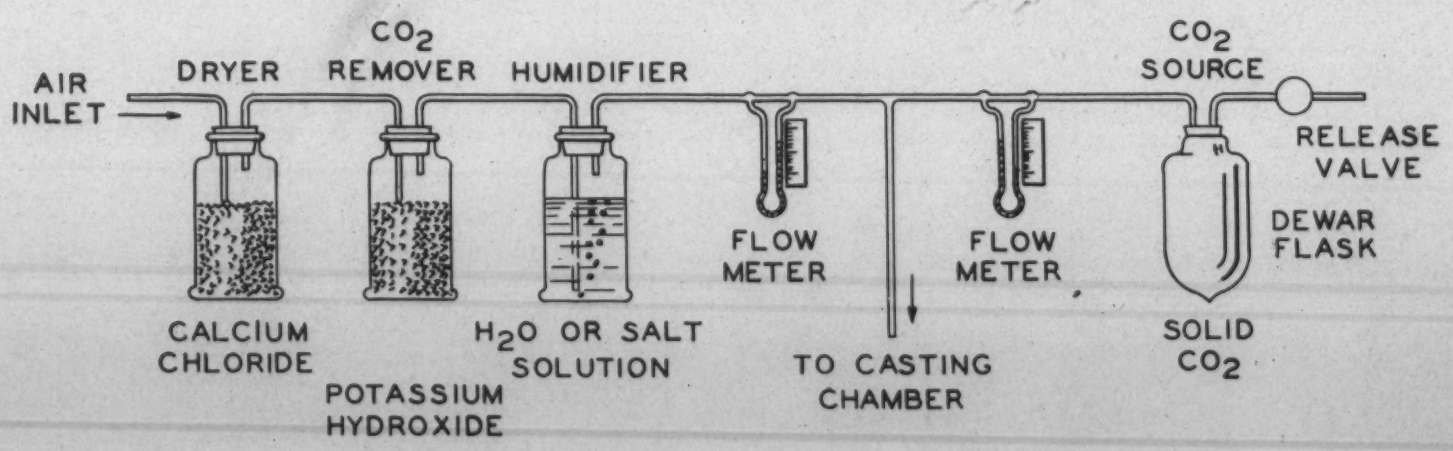
Early in the study of lead-calcium it was noticed that the molten alloys quickly filmed over with oxide. Careful observation of the characteristics of these molten alloys revealed no phenomena that varied sufficiently with calcium content to serve as a clue to the composition. However, when these alloys were chill cast with as little agitation as possible, the surface of the ingots became progressively duller with increasing calcium content to a certain value. Further increase in calcium content resulted in the fissuring of the surface oxide leaving bright metallic areas exposed. This fissuring phenomenon, which is illustrated in Fig. 1, is the type of composition-sensitive indicator desired. When samples of lead-calcium are melted and cast under controlled conditions the surface markings are reproduced with considerable fidelity in respect to areas of dull and bright surface. The ratio of these areas is dependent on the calcium content. For clearness of illustration the samples were photographed under lighting conditions that made the bright highly reflecting surfaces appear dark in the photograph.

The success of the method is dependent to a large extent on the details of procedure that are given below. Since calcium is readily removed from lead by oxidation, a melting and casting procedure for the test specimens was adopted that resulted in a minimum loss of calcium. Fluxes and inert atmospheres, which normally provide adequate protection against oxidation, could not be used here since they seriously interfere with the fissuring phenomenon that is the basis of the method.

Details of the New Method

The means finally adopted consists in melting a strip of the cable sheath to be tested in a hemispherical sheet iron crucible about 2 in. in diameter. A Bunsen burner flame of sufficient intensity to melt a 100-gram sample in about 2 mins. is applied to the bottom of the crucible. The bottom edge of the sample melts first and the balance of the sample slides smoothly into the pool of metal first formed with a minimum of rupture of the surface. The broad round shape of the crucible permits it to be

Fig. 3. Apparatus used for regulating atmosphere composition.



tilted until the lip is but a fraction of an inch from the surface of the mold before the metal starts to pour, thus subjecting the stream of molten alloy to only a brief exposure to the atmosphere during pouring. The molten alloy should never be stirred nor should the crucible be shaken unnecessarily during the casting operation. Under the melting conditions described, the casting temperature of the melt is controlled sufficiently if the crucible is removed from the flame 3 or 4 secs. after the last portion of the sample has melted.

By slight modifications in technique, samples for analysis may be taken directly from the commercial melting kettles. The mold used is probably not critical in shape or size. The one used in this development is an iron plate 3/4 in. by 4 in. by 8 in. with a tapered depression milled in its surface. The test ingot is about 4 in. long, 5/8 in. wide, 1/32 in. thick at the casting end and 3/8 in. thick at the other end. It weighs 80 to 100 grams. The effect of mold temperature has been studied and is not critical in the range from room temperature to that reached by the mold as a result of casting into it at intervals of a few minutes.

Atmosphere Control Necessary

Control of the atmosphere over the surface has been found necessary to insure reproducible results. For this reason the cellophane enclosed casting chamber shown in Fig. 2 was devised. There is a door on the right hand side for insertion of the crucible and a rubber inlet tube on the left for entry of the gas mixture. It has been found by experiment that both moisture and the carbon dioxide content of the air influence the results obtained. Therefore, both are removed chemically and then re-introduced in metered quantities to the air passing into the casting chamber. By means of appropriate flow meters, dry air could be mixed in definite proportions with air saturated with moisture to produce the desired humidity.

Another and perhaps simpler system is to pass the dry air over certain salt solutions of known vapor pressure. Carbon dioxide is conveniently made available by placing solid carbon dioxide (dry ice) in a Dewar flask having a stopper with two exit tubes. By means of an escape valve on one tube any desired CO_2 pressure can be built up in the flask to force the gas through a flow meter and into the air line leading to the casting chamber. One satisfactory arrangement of apparatus for controlling the composition of the atmosphere is shown in Fig. 3.

The surface appearances shown in Fig. 1 were obtained by casting in an atmosphere having 50 per cent relative humidity and 0.02 per cent CO_2. Increasing the carbon dioxide or decreasing the moisture content causes the surfaces to become brighter and vice versa. This provides a few thousandths of a per cent latitude in adjusting the sensitive range of the method to the median calcium content desired. Alloys having calcium contents outside the range of the method may be estimated by admixture with known amounts of lead-calcium alloys of known calcium content. Pure lead, in general, cannot be used for dilution because the oxide and possibly traces of impurities present in it cause the loss of some calcium from the mixture.

Chemical Lead Used

To date most experience with the use of the visual test for calcium has been on alloys made with chemical lead. This grade of lead is substantially free from arsenic, tin, bismuth, iron, antimony and zinc, and contains about 0.004 per cent Ni, 0.06 per cent Cu and 0.007 per cent Ag. The variation in concentration of these elements in the commercial supply has not been found to be great enough to cause serious interference with the indications given by the casting test. However, the method is influenced by certain variations in impurity content which are in excess of those normally encountered in the usual supply. The presence of tin in the order of a few thousandths of one per cent causes low indications of calcium content.

The use of high purity lead in place of "chemical" lead has a similar effect. Bismuth additions up to 0.1 per cent are inconsequential. Arsenic and antimony form compounds with calcium which dross off in the mixing kettle so that these elements would not be found in the finished sheath. The effects of the interfering impurities referred to above can be corrected for, when their presence is known, by varying the atmosphere in the casting chamber or by admixture with a known proportion of alloy having a pre-determined higher calcium content. By these procedures fissuring can be made to occur in alloys that otherwise do not give this manifestation. In practical operation the brand of lead being used will be known and the necessary adjustments can be made in the conditions of the test.

Sufficient analytical data have been collected to establish the fact that the method here presented is rapid, reliable, and extremely helpful for plant control application.

Highlights in Making Go

A Pictorial Presentation

In making gold filled metal for spectacle frames, the American Optical Co. of Southbridge, Mass., oldest and largest manufacturer of ophthalmic products in the world, undertakes all steps, from the selection and use of raw materials to the final shaping and assembly of the finished spectacle parts. This complete control is necessary because of the many variations in physical properties required for the different parts of a spectacle frame or mounting.

Rigid standards have been set up by which the physical and chemical properties of spectacle metal may be controlled. These properties embrace such characteristics as strength, hardness, flexibility, appearance of the finished metal, its ability to withstand abuse, and its resistance to corrosive action of body acids and the atmosphere.

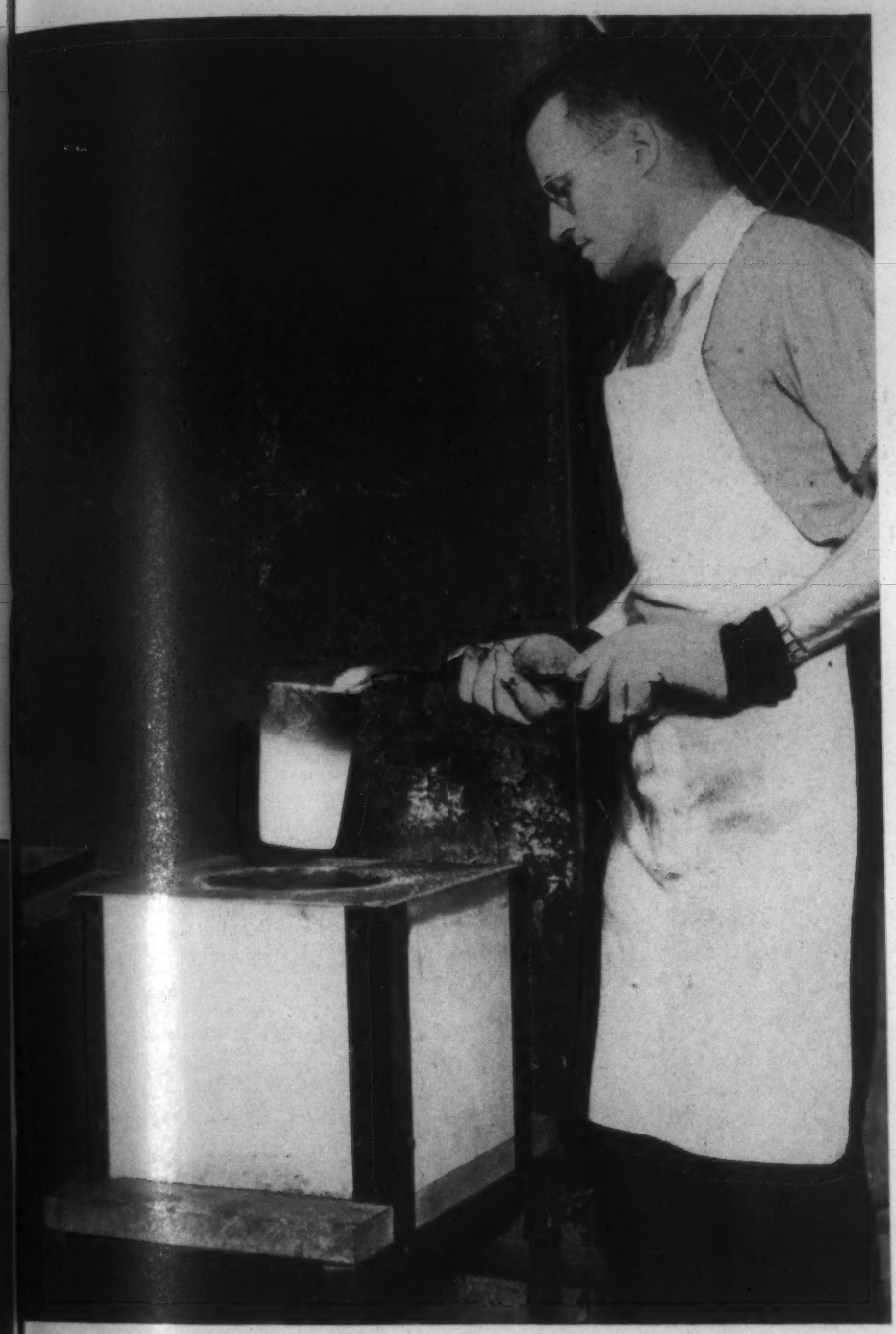
Shown in this presentation are highlights in the art of preparing gold filled metal for spectacles, as practiced by American Optical Co.

by W. J. Wrighton

Chief Metallurgist, American Optical Co., Southbridge, Mass.

The manufacture by American Optical Co. of spectacle frames begins in the laboratory. From every lot of gold alloy, an assayist takes a sample, melts it in a crucible, and arrives at an accurate proportion of pure gold vs. base metal content. Assaying is of great importance because it is the first step in quality control—a control which insures the production of spectacles giving the highest degree of comfort and long wear.

Gold Filled Metal for Spectacles



First step in the actual manufacture of spectacle frames, as shown above, consists of melting in an induction furnace 12-carat gold, composed of pure gold and various alloying elements. It is essential that the melting of the alloy be kept under accurate control to produce sound ingots.

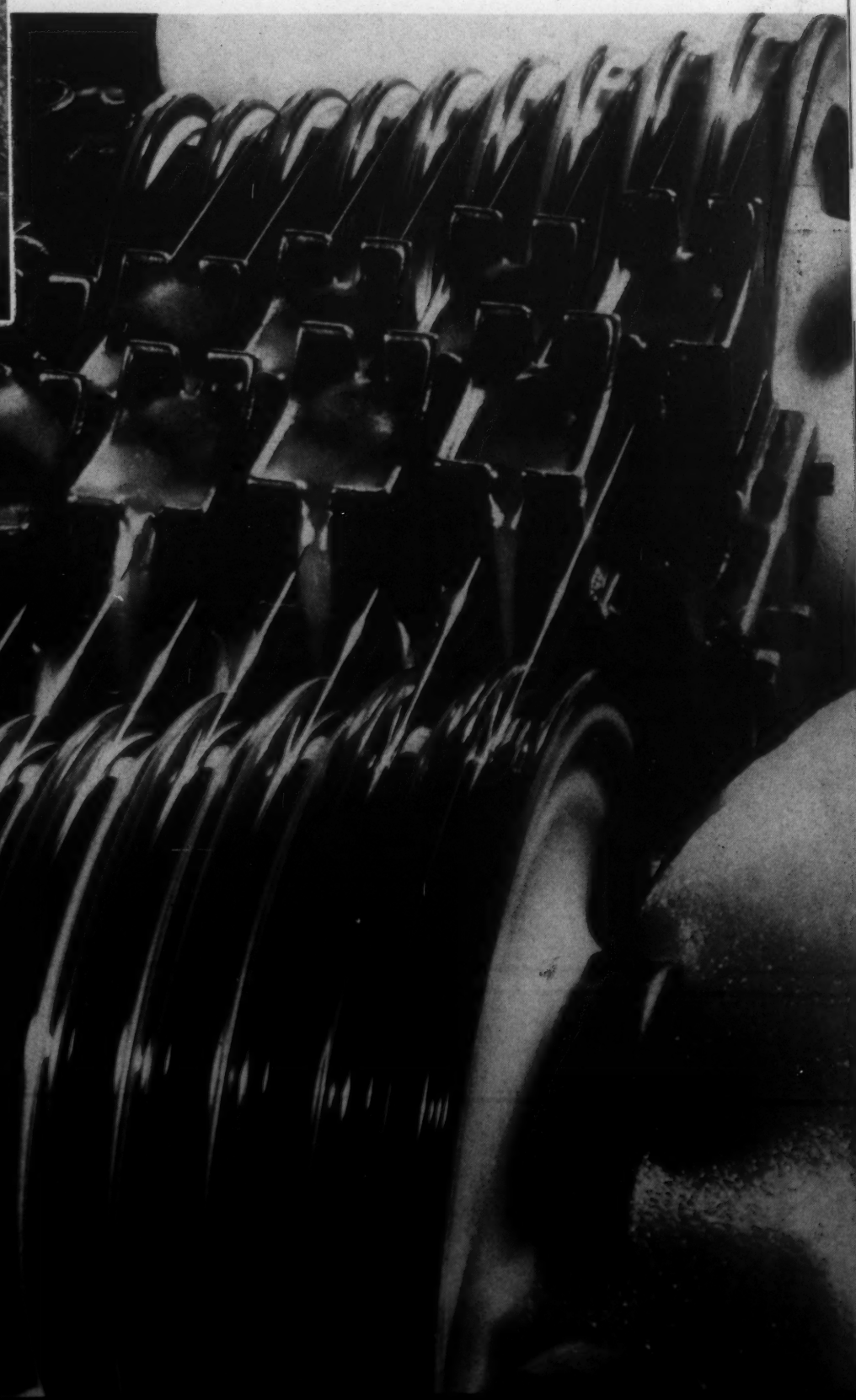
The gold alloy, transformed into a well-mixed glowing fluid, is taken from the induction furnace and poured into a mold.

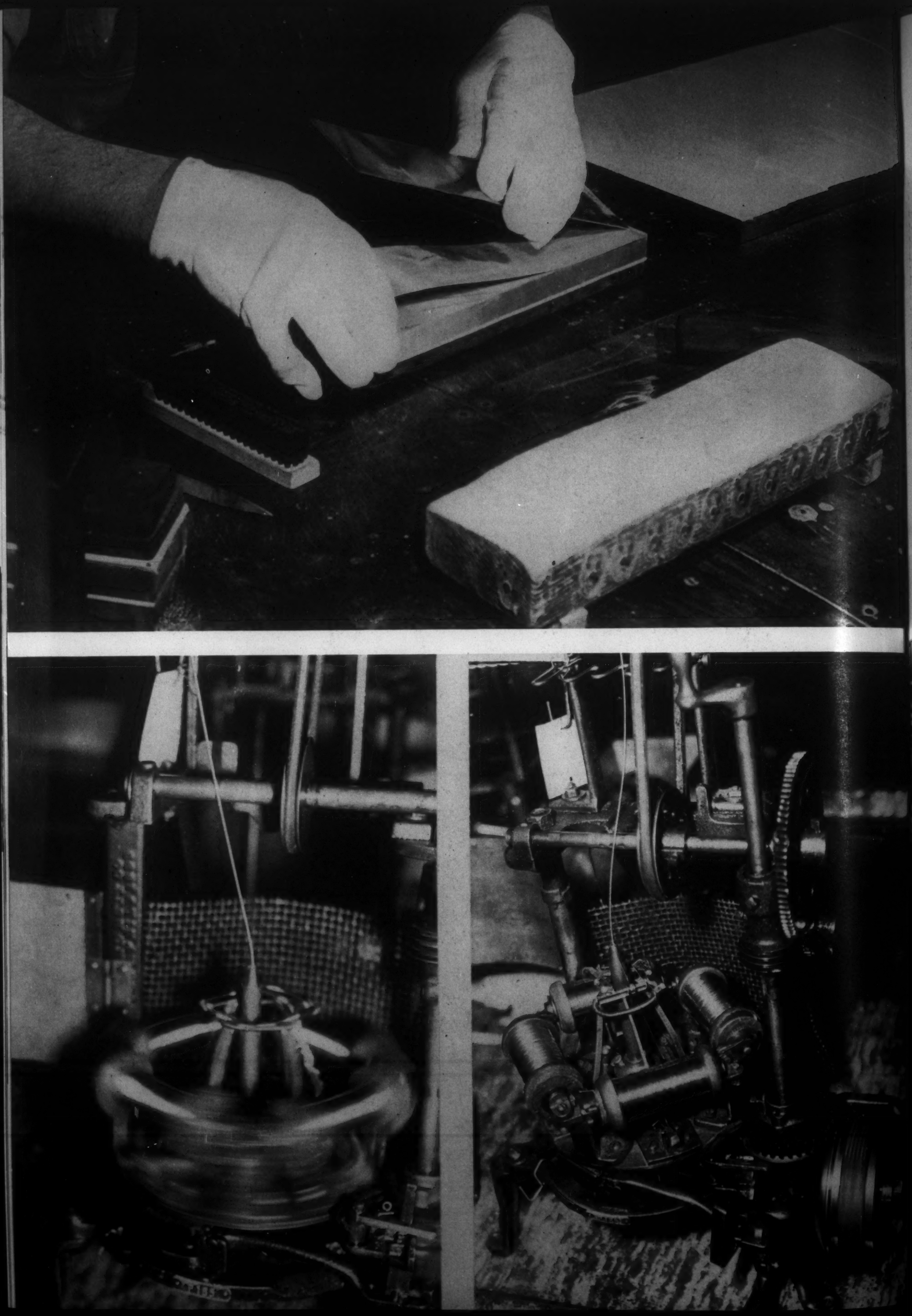
The 12-carat gold alloy, after being rolled, is soldered to an alloy base plate. The composite plate is then rolled into a sheet and a disc blanked. From this disc, after several drawing operations, a tube with the gold on the outside is formed. The tube is about a foot long and an inch and a quarter in diameter. The press used for the drawing operation is shown.

The gold alloy shell is slipped over a base metal core wrapped with silver solder, after which the bar is drawn through a die. The gold filled bar is then soldered in an electric furnace.

The bar is then rolled, as shown above, until its original length has been stretched to a point where it can be cold drawn to the required size for various parts of spectacles.

In some cases, such as in the making of cable for the earpieces, or temple-ends of spectacles, the original foot-long gold alloy bar is drawn down to fine wire more than three miles in length. The picture below shows gold filled wire being drawn through diamond dies.



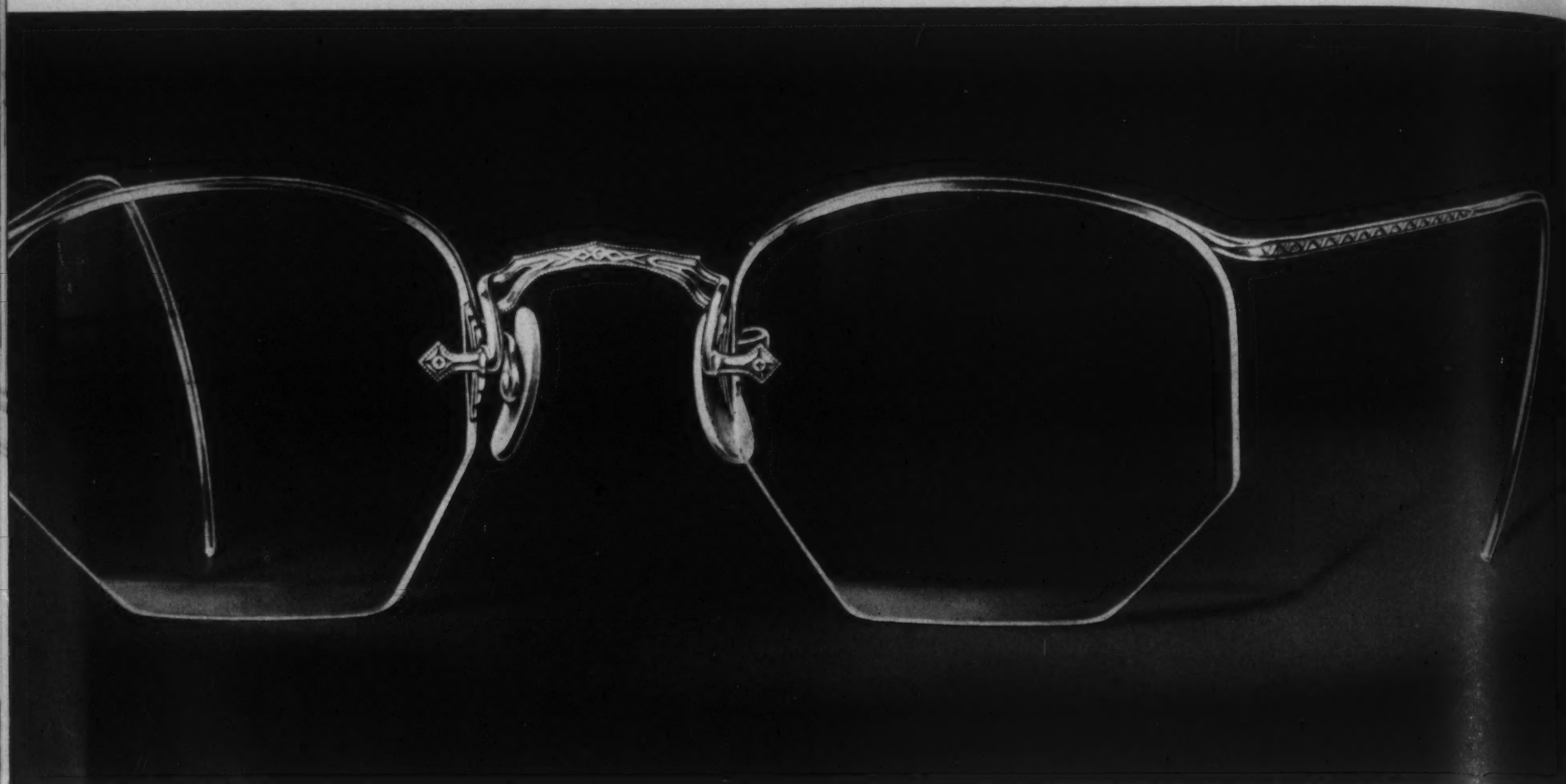


Left: To make certain parts of spectacles like bridges, endpieces, straps and such articles where it is impossible to use round wire, flat gold filled stock is needed. This is formed by soldering a bar of gold alloy to a bar of base metal. The alloy bar is then rolled to various thicknesses.

Lower Left: This machine winds cable for spectacle temples. The inside windings are generally made from alloyed wire, while the outside winding is made of gold filled wire.

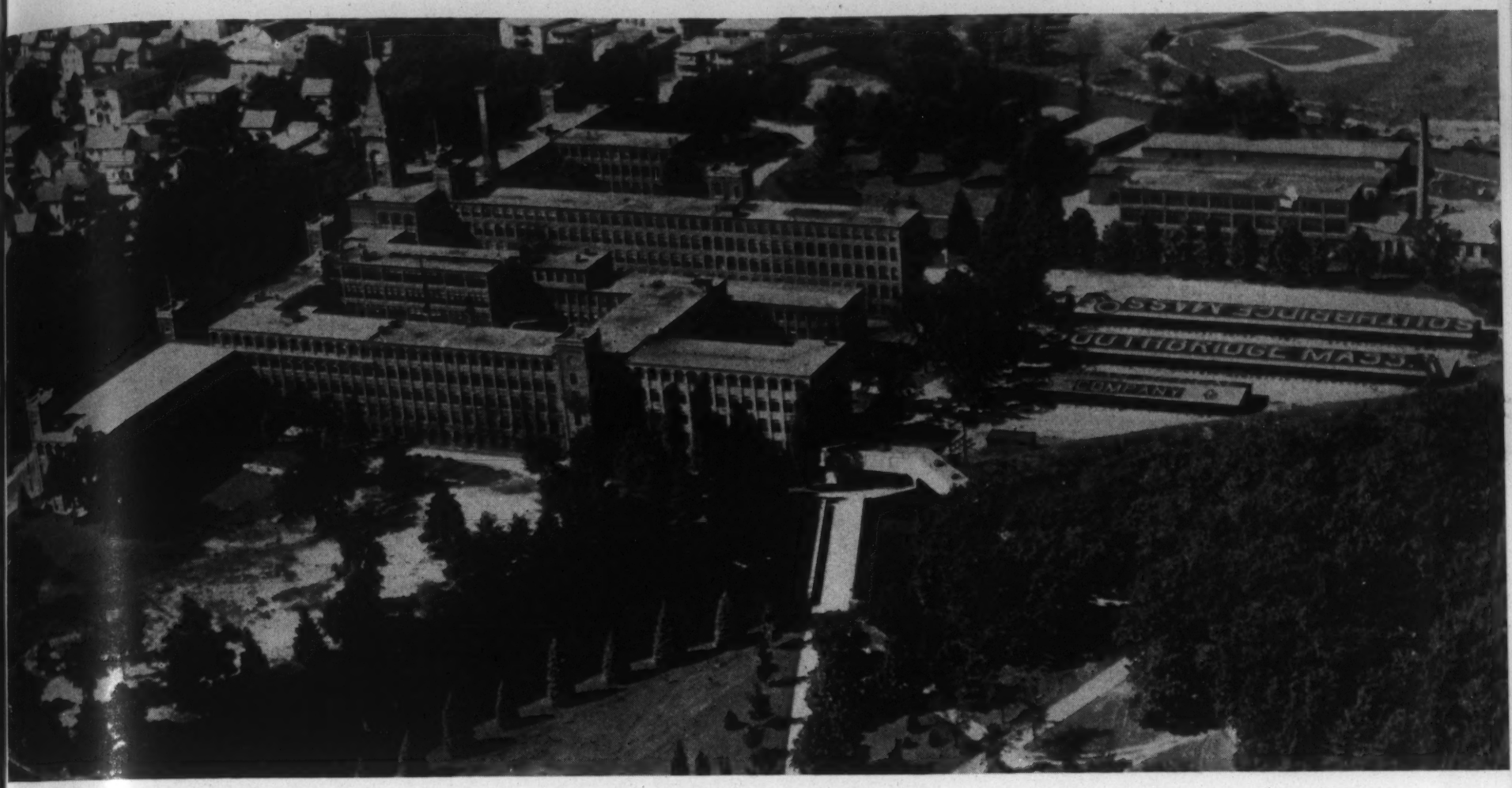
Scientific control governs every step in processing gold filled metal for spectacles. Here an operator gages the gold strip as it emerges from the rolling machine.

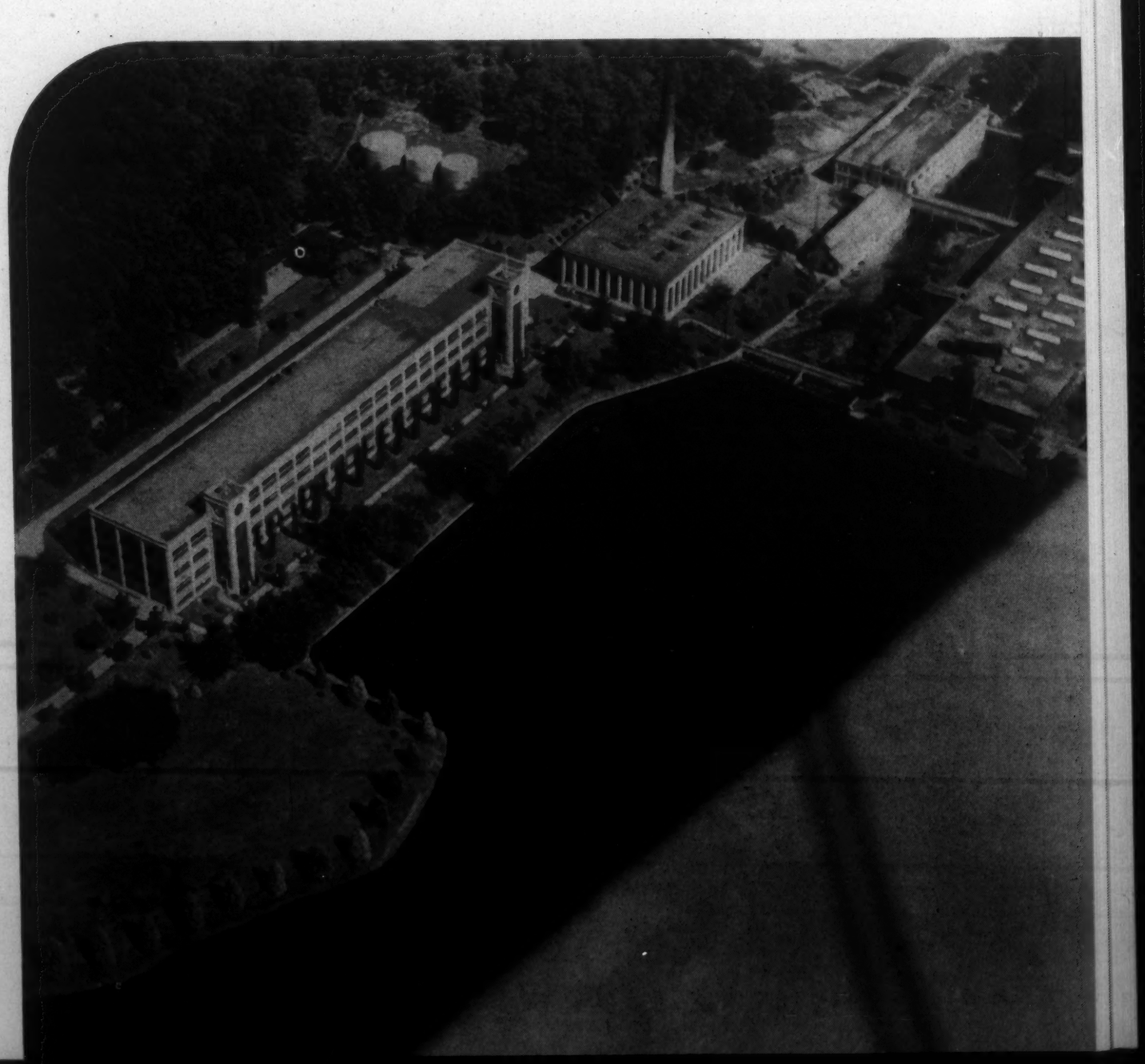
Here is the final destination of the gold filled metal—a spectacle of the latest design and type, ready for its extremely important duty of helping to correct defective eyesight.



This pretty miss is living proof that the modern streamlined spectacle does not detract from one's good looks.

The airplane view below shows the main plant of the American Optical Company, Southbridge, oldest and largest manufacturers of ophthalmic products in the world. Here scientifically-controlled gold filled metal is manufactured for fabrication into spectacle frames.





This is Lensdale, lens-manufacturing plant of the American Optical Co. Annually millions of ophthalmic, sun glass, and safety lenses are made here.

ably the product of necessity. The lack of understanding, which it is true, did at one time exist between the metallurgist and the engineer, showed that a man who was broadly trained in both metallurgy and engineering was required to solve the complex problems arising in metal-production and metal-working plants.

Today, therefore, a large and still-growing proportion of the men who hold responsible positions on the operating and engineering staffs in the metal industries have *both* a good knowledge of metallurgy and some sound, practical engineering experience.

These men work with metals. They are familiar with the behavior and performance of materials. They know engineering design. And they are well acquainted with the problems encountered in production. With this background, they can ably decide on materials, design and methods of production. Here there is no quarrel between the metallurgist and the engineer. These men *are* the real metallurgist and the real engineer combined in one who needs only to cooperate with himself.—H. R. C.

A Letter to the Editor

The Mild Alloy Steels

To the Editor: It is not often perhaps that an editor accepts as fully the viewpoint of one presenting such a highly complicated discussion, as you did in your editorial entitled "Mild Alloy Steels—To Use or Not to Use," printed in your November issue, commenting upon an article of mine entitled "The Light Weight Development—For Whom and What?", which appeared in the August 2nd issue of *Railway Age*. Your interest is gratifying, and can be taken as a measure of the importance of the subject. There are portions of the editorial, however, which do not quite jibe with the facts.

You state that "the car designs in use (of mild alloy steel) are for cars of the same capacity as those made of plain steel." This is not the case wholly. The cubical capacity has been increased in a majority of the open top cars which have been built of these steels, and consequently they do take advantage of their lighter tare weight. While as you say, the cost of these structures per unit is frequently no less than the cost of outmoded equipment in carbon steel, nevertheless the cost per ton of capacity is lower in practically all cases. The argument that dead weight is a small factor because "freight cars aren't always in motion" is irrelevant, because the cost figures are calculated upon the average number of miles which the cars actually *move in service* annually, loaded and empty. Moreover, cars should be designed for low cost operation, since it is their function to move.

The railroads do themselves little service in claiming small benefit from the modern equipment, "because it is so frequently on the lines of foreign roads." On this basis outmoded car design would remain frozen on all roads, progress would cease. However, the statement itself is incorrect. The report published in 1941 by the Association of American Railroads, Operating Statistics, Series 173-F, indicates that of the total freight cars on line, the percentage of home cars in 1939 was 64.4% and in 1940 62.4%. Also, the light weight development would register a marked advance if roads which operate what amounts to a shuttle service *over their own lines with their own equipment* would step up and buy.

The large companies, who build a majority of all railroad cars, are now equipped to take full advantage of the superior properties of the new steels in modern welded designs.

There is a good bit to be said with reference to your statement that "stressing of corrosion resistance may be in order in the case of freight cars, but, with the good atmospheric corrosion resistance of most of the mild alloy steels and the fact that things usually are painted, this argument has never impressed us as the correct main talking point for this class of steels." These steels *should* find their largest market in freight car construction, and were introduced in the railroad field for this type of equipment. Your reference to "the good atmospheric corrosion resistance of most of the mild alloy steels" is fine, and we agree, but our plea is that the railroads are not making use of them as readily as we think would be to their profit. We stress the corrosion problem, hoping they will adopt the remedy.

By long odds, corrosion attack is most injurious in open top equipment. The interiors of such equipment, comprising approximately one-half of the freight cars owned, are not painted. The balance of the cars owned are principally of the box car type, and in these condensation, or sweating, presents a corrosion problem which cannot be wholly prevented by paint. No railroad engineer that we have encountered will advocate a reduction in the thickness of freight car body sheets, in order to eliminate dead weight, without first knowing that the steel to be used possesses added resistance to corrosion, and sometimes abrasion and mechanical damage. This is because a service life is demanded at least equal to that which has been experienced in the past with ordinary copper bearing steel equipment.

The economies of dead weight elimination outweigh those of reduced maintenance and extension of service life. One railroad—the perfect example we admit—claims that it will enjoy large returns from its investment in lightweight equipment, even though, contrary to its belief, maintenance costs should prove somewhat higher than it has experienced with cars of heavier section in copper bearing steel. Each of its cars carries five tons of additional lading—625 added tons to the train of 125 cars. This payload is carried absolutely free when compared with the cost of hauling the same type of lading in its heavier cars of lower capacity.

FREDERICK D. FOOTE

Alloys Development Corp.
New York and Pittsburgh

METALLURGICAL ENGINEERING news

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Defense Perspectives

by H. R. Clauser
Assistant Editor

Out of the mountain of defense news each month, there are always a few highlights that command the major interest of the metallurgical engineer. Perhaps the most significant action this month was the beginning of the gradual adoption of total allocation of vital materials to defense.

Steel was battered from all sides. Strikes, scrap and raw material shortages harassed production; the pressing problem of supplying specific types and shapes as well as coordinating deliveries with production schedules in fabricating plants appeared increasingly formidable.

The non-ferrous metals industries were likewise beset with a variety of problems. Magnesium, copper, lead, tin, cobalt and nickel all are scarce and looking forward to expansion programs. Only in aluminum was there an optimistic note and even that will hardly be noticeable before 1943.

Total Allocation

It seems that the allocation system, which came into being last month, is more than anything else an attempt to solve the distribution problem and to prevent accumulations or hoarding of vital supplies by any one or group of fabricators. Under the strict priority system, the tendency was for the vital defense plants to stock-up on all the materials necessary to complete an order, regardless of the length of time required to finish that order. This, of course, caused shortages in some defense plants while the supplies they needed lay idle in stock piles.

Under the allocation system, which will not invalidate the priority system but will work in conjunction with it, the orders for large blocks of supplies will be placed for shipment over a given period of time. Then it will be the job of the allocations board to portion out, by relative importance and from information gained from inventory reports, the supplies or products available in any one month to the customers whose requirements should be filled within that time.

Pig iron and steel plate were the first to be put under total allocation; other metals and metal-forms are being added constantly. In any case, however, full control of distribution will only be applied to those products and supplies that are most vitally needed for defense and whose control is necessary to assure efficient functioning of the defense program.

Iron and Steel

While Labor, the Administration and the steel industry debated, the captive coal mine strikes, including the one at the end of October, caused the loss of at least ten days' coal production. These latest strikes brought the estimated total steel ingot tonnage loss due to work stoppages up to about 700,000 tons since April 1st.

On Armistice Day, in Washington, the iron and steel men met with the iron and steel branch of the OPM to discuss their common problems. From that meeting came a clear-cut picture of the present status of this most vital industry and what could be expected of it in the future.

It was pointed out in this column last month that the entire steel expansion program depended upon coordinating the plans of all the factors involved in steel production. The iron and steel meeting brought out the fact that plans for increasing pig iron capacity were out of balance with the rest of the program, and that in order to bring these plans into balance by 1944, it would be necessary to build about 32 additional blast furnaces.

There is a scrap crisis, and no one knows exactly what to do about it. The scrap problem is difficult and bewildering because there is no definite, detailed information about the sources of scrap or its consumption. The Bureau of Mines is getting this detailed information now, which may help ease the situation.

In the meantime, scrap is being allocated arbitrarily to those plants on defense work who are found to be in desperate need. The point remains that throughout the emergency there will be an acute shortage of scrap about which little can be done.

Next to the pig iron and scrap shortage, the meeting of the iron and steel men stressed the deficiency in supplies of specific types of steel, such as plates, shapes and high-alloy steels, and also in coordinating deliveries of steel with the production schedules of the ship yards, tank, ordnance and other fabricating plants. Only long-term planning on the part of the large fabricators in cooperation with the government and better timing in moving steel from mills to fabricating points will correct these conditions.

A. D. Whiteside, chief of the iron and steel branch of the OPM, summed up the steel situation very well at the meeting of the iron and steel industry when he said that we will have no more steel in 1942 or 1943 than we have today—slightly less in '42 and slightly more in '43. The average will be the present production.

Non-Ferrous Metals

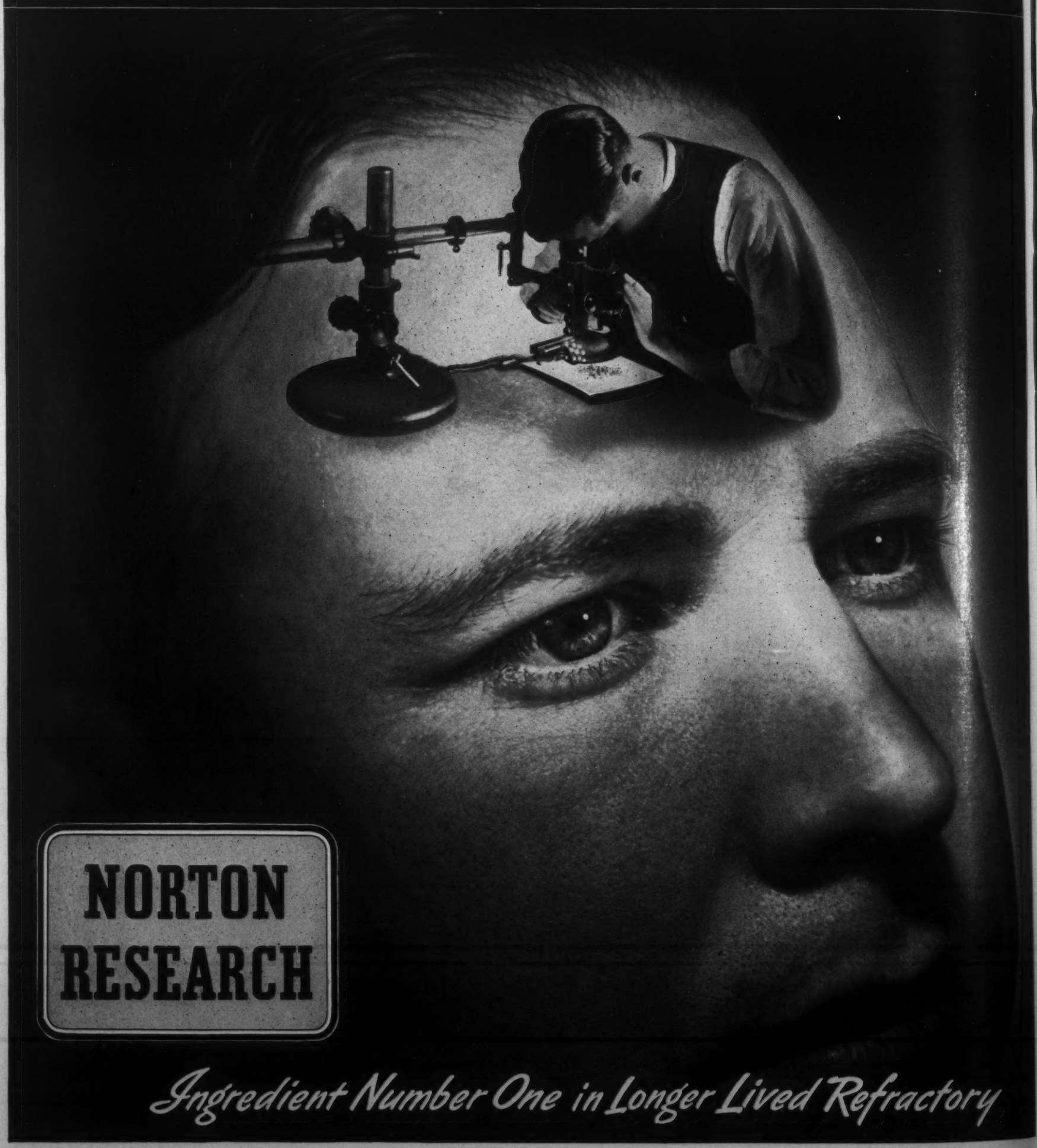
Increasing shortages in most critical non-ferrous metals and the consequent tightening of their control was clearly evident last month.

Magnesium was put on a complete allocation basis. Really a war baby, magnesium production is advancing so rapidly that it is difficult to put down anything definite about it. Right now, as far as can be determined, at least four different plants are being built in various parts of the country to increase production by around 70,000 tons.

The predicted production figure for 1942 of 56,000 tons, reported here last month, has been boosted to 160,000 tons, and as

(Continued on page 882)

GRAINS + BRAINS



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FIRING LINE NEWS

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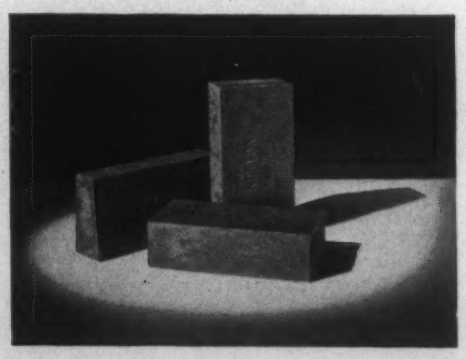
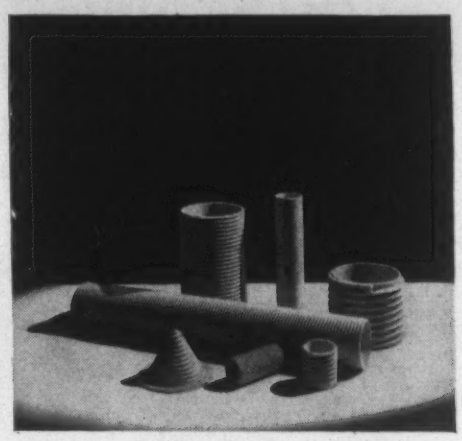
—long-lived refractoriness, without spalling, softening or deformation.

Long-term refractory costs are lowered by use of ALUNDUM muffles. Still more vital to you today, is prevention of shutdowns for rebuilding furnaces.



CRYSTOLON (SIC) Pier Brick Stand Up Under Great Heat and Heavy Loads

The double strain of constant direct exposure to elevated temperatures in enclosed chambers — plus bearing the weight of a heavy structure — shortens the life of most pier brick used in furnaces for galvanizing wire, etc. CRYSTOLON pier brick, however, can take it. Refractory without spalling, softening or deformation up to 1650° C., silicon carbide is also one of the strongest materials known to man. In longer life, and prevention of interruptions to production, it pays its way over and over.



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For your laboratory's combustion or incinerating furnaces, drying ovens, wire drawing, heat treating or metal melting furnaces — ALUNDUM (Al_2O_3) cores offer in the highest combined degree, refractoriness, strength, electrical resistance and chemical stability. Made in a wide variety of spirally grooved sizes and shapes. WRITE FOR USEFUL MANUAL "The Construction of Electric Furnaces for the Laboratory."

In W, Mo, Cemented Carbides — 4-Fold Furnace Tube Life

To meet today's demands for 24-hour operation at around 1700° C., with maximum refractory life to prevent shutdowns — Norton engineers recently developed a new tube for furnaces used to heat-treat cemented carbides and tungsten or molybdenum wire. Norton's RA98 furnace tubes had set the pace for long life under the most difficult operating conditions, *but the new mix, RA1139, stretches furnace life as much as from 12 weeks to 12 months*. This new mix is applicable to tubes, cores and muffles.

Refractory Shapes and Cements of CRYSTOLON (silicon carbide), ALUNDUM (fused alumina), and fused Magnesia Grains

NORTON COMPANY, WORCESTER, MASS.

proposed by the OPM, will eventually reach 200,000 tons per year. This year's production will be around 30,000 tons, which will be 10,000 tons less than the demand.

Lead consumption has rapidly increased with the demand for its use as a substitute for copper, zinc and aluminum. At the beginning of the month, Leon Henderson claimed that most of the industry was not working at near full capacity and that lead output could be increased. Any increase in lead production would also increase the zinc output, since the two metals are mined together.

Cobalt, like so many other metals, has passed to a direct allocation system, because of the shortage and uncertainty of shipments from abroad. The estimated requirements for 1942 are 400 tons more than this year's production in the United States. Since cobalt is used in the production of high-speed cutting tools, assurance of its supply is imperative.

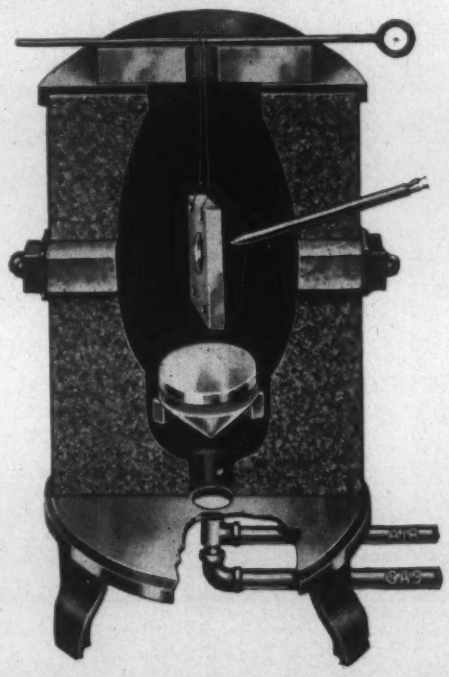
Aluminum is on its way out of the critical stage, and from most reports, it looks as though the supply may very nearly approach the demand after 1942. Until then, however, aluminum production will not be able to do much more than take care of the aircraft industry, which will demand 70,000,000 lbs. per month.

November saw a copper shortage of about 7,000 tons. The figures for next year indicate an estimated shortage of 750,000 tons. Various means of cutting down this figure have been recommended. The Army ordnance is seriously considering the use of soft, low-carbon steel in place of cartridge brass. Shell casings alone require 600,000 tons of copper per year. It has even been suggested that the silver now stored away at West Point be melted down for bus-bars and used in place of copper in power plants, etc. The automotive industry has already agreed to use steel instead of copper for automobile radiators.

Nickel production was announced to be up to about 8,500 tons per month, but the supply is not nearly enough to satisfy the need for this vital alloying element. Ways of reducing its use are being sought, and some thought is being given to eliminate its use in armor plate, which, at the present time, cuts deeply into the nickel supply.

NOW—the heat treating furnace that Industry always wanted at half the price you'd expect

THE INTEROVAL FURNACE is the product of almost a half century of heat treating experience. Its design is just engineering common sense applied to the problem of hardening expensive tools and dies safely and accurately. No possibility of surface decarbonization or distortion. Of particular importance at this time is the outstanding ability of this furnace to heat treat "Moly" steels without any trace of scale or soft skin. Read the description below and then send for our new folder, giving complete information.



Sectional View of Interoval Furnace, showing method of suspending the work. Note location of deflector and shape of chamber.

INTEROVAL DETAILS

Overall size — 32" high x 20" in diameter.

Heating chamber—14" high, 9" in diameter at center, 7" in diameter at top.

Weight—550 lbs.

This furnace is gas-fired and can be operated at an average cost of 25¢ per hour for fuel. It heats entirely by radiation, the work being absolutely untouched by products of combustion.

Pieces are suspended by wire, eliminating possibility of distortion. Heats to 2350° F. in 40 minutes. Non-oxidizing atmosphere. Two openings at opposite sides of furnace permit localized hardening of tools. Heat resistant tray inserted through openings can be used for hardening small parts. These openings are also used for heating small parts for forging. May be quickly converted into lead, cyanide or salt bath furnace.

Bennett INSURED STEEL TREATING CO.
130 SOUTH ST. - - - NEWARK, N. J.

● The School of Technology of the *City College of New York* plans to offer a defense course in powder metallurgy. The course will cover the properties and methods of utilization of powdered metals and will get under way late in December, 1941.

Spectrographic Analyzer

A rapid and convenient method for analyzing spectrographic plates or films in research and industrial laboratories is provided by a new recording microphotometer recently announced by *Leeds & Northrup Co.*, Philadelphia.

Because the plates or films are mechanically scanned by a motor-driven Scanning Unit, and the relative positions and densities of spectrum lines are automatically recorded, it is said that this new recording microphotometer eliminates the eyestrain and "human equation" of visual methods, and does away with the delays and limitations of photographic processes.

Quick determinations of elements present in small percentages are made possible by pen-and-ink records of standard and test spectrograms drawn at high speed on one chart.

Million-Volt X-rays

If Roentgen were alive and could have attended the million-volt industrial X-ray symposium held recently at the *General Electric* plant in Schenectady, he would have learned just how far the use of X-rays, which he discovered, has progressed since the modest beginning in 1895. For the symposium was indicative of the rapid development that industrial radiography has experienced from the use of large, unwieldly, low-voltage equipment as recently as 10 years ago to the present-day apparatus, which is portable, compact and capable of voltages up to 1,000,000 volts.

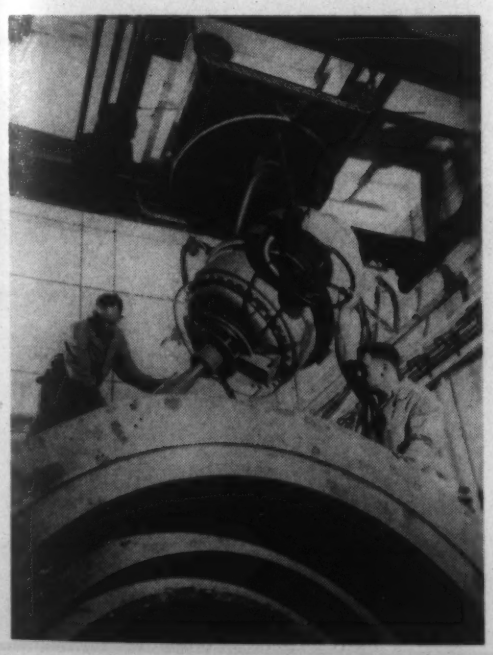
The Need for High Voltage X-rays

Until the development of the million-volt X-ray unit, the use of X-rays to examine heavy castings and weldments was somewhat limited by the radiographic facilities available. In cases where a section 3-5½ in. had to be radiographed, either 400,000-volt X-rays or gamma-rays were used. The time required, if a number of pictures was necessary, ran into days, sometimes weeks.

The million-volt X-ray equipment makes possible the penetration of 4½-in. steel in approximately 2 min., whereas 90 hrs. exposure time would be required for 400,000-volt X-rays, or around 60 hrs. for 200 milligrams of radium. This is a decided economic advantage.

Not only is the million-volt X-ray apparatus advantageous by reason of reduction in exposure time, but also because of the improved quality of the radiographs obtained. At 400 k.v.p., the X-rays are not of the proper wave length to give satisfactory results for plate thickness ranges of 4-5½ in.

Using the 1,000,000-volt industrial X-ray equipment for an inspection of a casting.



The wave length of gamma-rays, although far less than those developed by 400,000 volts, give a radiograph whose contrast is not as good as that possible with X-rays of the proper wave length. The X-rays available with million-volt equipment are of a wave length that gives a highly satisfactory radiograph where heavy sections are involved. So, by the introduction of the million-volt apparatus, the necessity of over-reaching the better technique range of lower voltage equipment is eliminated and a better radiograph is obtained at a great decrease in exposure time.

Design

Three novel developments have been largely responsible for the evolution of a practical million-volt X-ray machine. One is the use of a gas—Freon—under pressure as an insulating medium in place of oil. This gas, which is a compound of carbon, chlorine and fluorine, at 50 lbs. per sq. in., has a di-electric strength 3 times as great as the purest transformer oil.

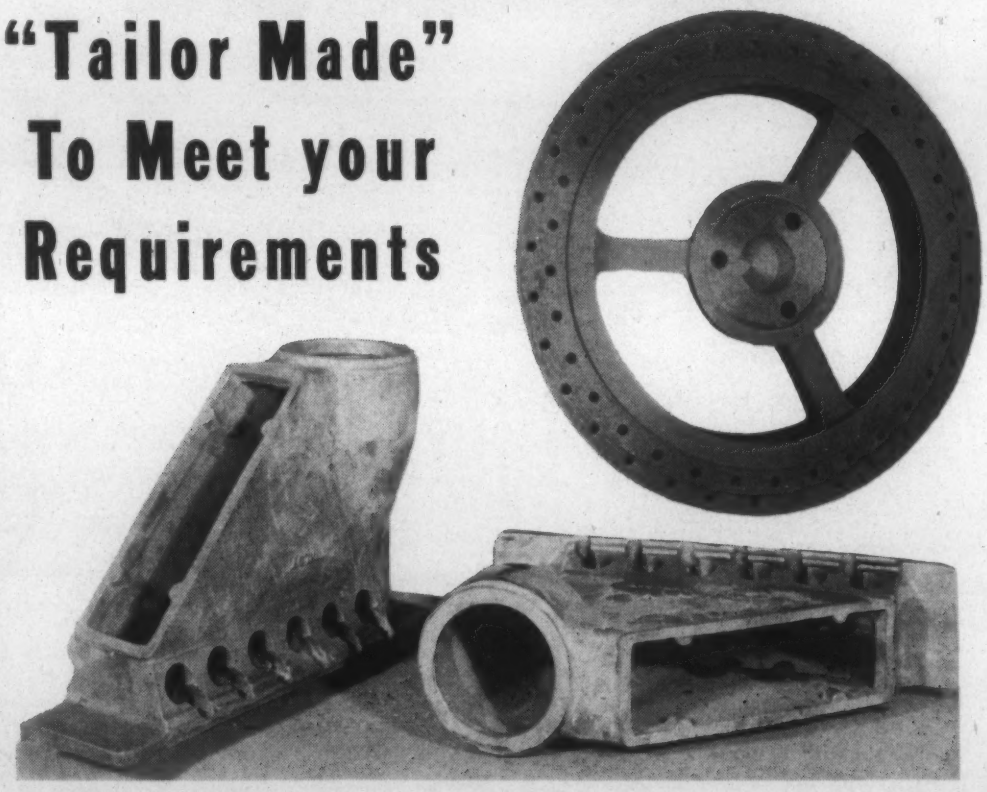
Another development responsible is the use of a resonance transformer without an iron core. This is made possible by the several hundred thousand turns of wire around the secondary, giving it great inductance. It thus tunes normally to alternating current, which oscillates 180 times a second.

The other development is the sealed-off multi-section X-ray tube, which fits efficiently in the center of the resonance transformer where the iron core would ordinarily be located. The X-ray tube has 12 sections. The electrons to produce the rays emanate from a heated filament at the top; as they pass through each section, an addition of 84,000 volts is applied, so that when they reach the bottom there are

DURALOY

CHROME IRON CHROME NICKEL CASTINGS

"Tailor Made" To Meet your Requirements



ONE can visualize countless different combinations of chromium, nickel, molybdenum and other alloying elements for producing high alloy castings. And the behavior of these castings varies with the analyses.

The point is that only those who are long-experienced in producing the so-called stainless steel castings are qualified to know which combination is best for each job and how to produce the casting. Then the casting is "tailor-made."

Duraloy, with 20 years' experience in making chrome-iron and chrome-nickel castings and with a modern, well-equipped foundry, has a casting service which should be of value to you.

Let us quote on your current requirements. Let us help you design new temperature-resisting and corrosion-resisting parts.

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12-DU-4

a million volts behind them.

The electrons then hit a tungsten target in an extension of the tube, which projects from the bottom of the tank, and X-rays are produced. The equipment allows the use of either the reflected or transmitted beam; this is very advantageous in casting work or where radiographs of circular seams on boilers are required.

As in all practical radiography, scattering of X-rays both forward or backward must be guarded against when using the million-volt machine. Back scattering can usually be minimized by simple precautions. To control forward scattering, lead filters may be used with the film. For example, lead foil filters from 0.030 to 0.060 or 0.090 in. are used, depending on the position of the film with respect to the object surface.

Typical High Voltage Installations

A number of high voltage units have already been installed. *Babcock & Wilcox Co.* were in need of a more rapid method for the X-ray examination of welds in heavy boiler drums. Since the Boiler Code requires all welding to be radiographed, the time required for a complete radiographic examination by either 400 k.v. X-rays or gamma-rays was often nearly equal to that required for the fabrication of the drum itself. The million-volt X-ray installation has eliminated this bottleneck.

Combustion Engineering Co. had much the same problem of cutting down the time for the radiographic examination of welded pressure vessels. Now, with the high-powered unit they are able to X-ray an entire circular seam of a boiler drum in one set-up, where formerly with lower voltage X-rays as many as 12 different exposures or more were necessary.

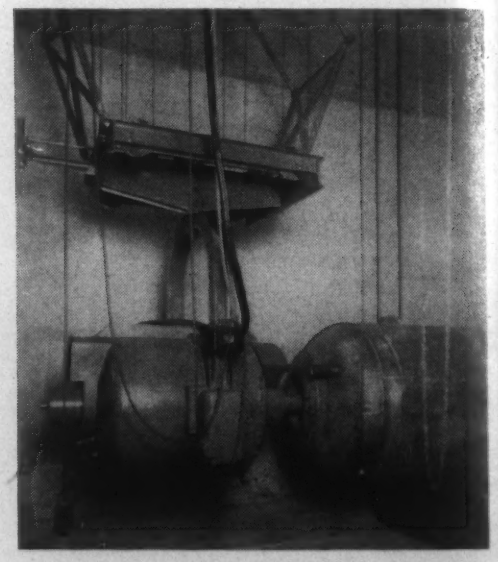
Ford Motor Co.'s interest in the installation of a million-volt unit was to gain its technical advantages in the examination of heavy individual castings or weldments as well as using it for the semi-mass production in the radiography of heavy steel castings. For example, in the mass production of cast crankshafts for aircraft engines, the X-ray examination of 40 crankshafts per day using units of 400 kilovolt capacity required 6 times as many man-hours as is required with the use of the million-volt unit.

Two other installations are the General Electric Co., and American Steel Foundries.

Low Voltage X-rays

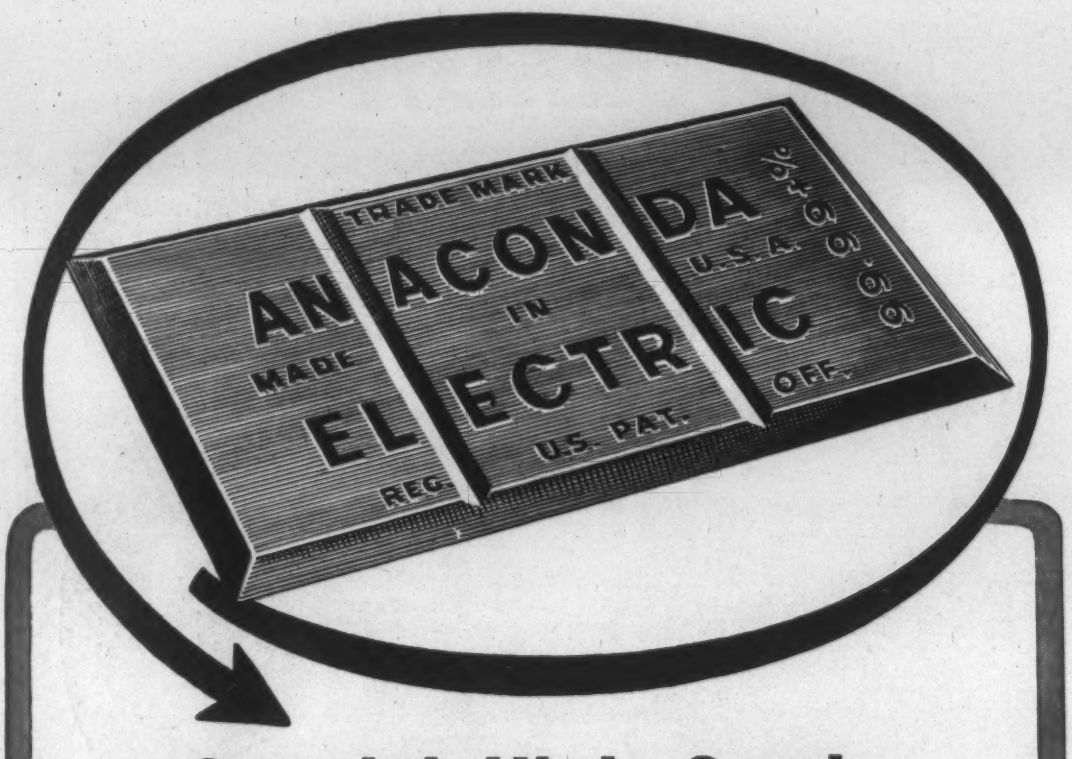
One important fact pointed out at the symposium was that all X-ray apparatus operating at less than a million volts has not been rendered obsolete for industrial purposes by the million-volt equipment. Lower voltages are preferable for X-raying aluminum, copper, brass and thinner sections of steel. Voltages of only around 50,000 are used for diffraction studies of atomic structure of matter. This application is very important and will see increasing use in the future.

X-raying the circular seam of a pressure vessel.



Still lower voltages down to 5,000 volts are being used in micro-radiography, which seems to have broad possibilities in the metallurgical field for the study of details in the structure of metals previously obtained only by micro-photography.

In conclusion, it can be said that industrial radiography, with its wide range of voltages, making possible a great variety of uses and applications, has become a valuable tool to the metallurgical engineer. Because of his desire to peer into the inside of things, industrial radiography will see even more progress and refinement in the future.



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99.99+% ZINC

To producers and users of zinc die castings, we say simply this: *Specify Anaconda Electric,* for you may be sure that every slab is of uniform high purity. Electrolytic refining does it. 39393

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Grinding and Polishing Equipment

For polishing and buffing jobs on such work as aluminum pistons for aircraft engines and fuse bodies, *Hammond Machinery Builders, Inc.*, Kalamazoo, Mich., has developed a rotary automatic polishing machine. The polisher consists of a circular aluminum table mounted over a heavy cast-iron base.

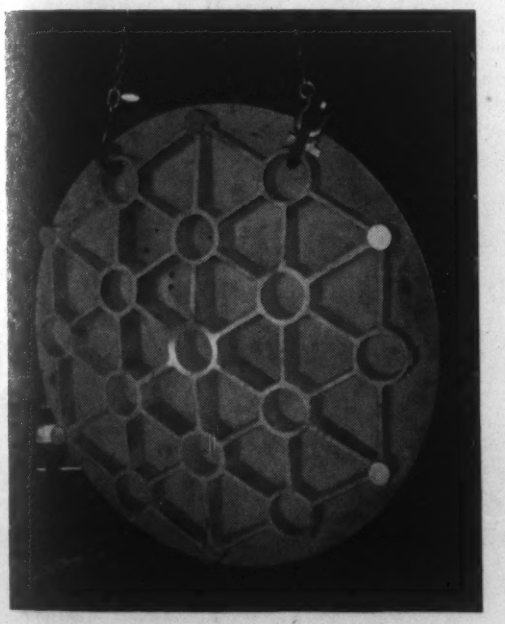
The table indexes automatically, rotating 6-8 chucks, which pass under as many as 4 polishing heads mounted in pedestals that stand on the floor around the machine.

A new tool vise, designed for grinding chip-breaker grooves into the tips of carbide tools has also been put on the market by the same company. The vise is mounted on a lug base and is constructed on a double-cradle principle, which permits adjustment of grinding angles on 3 separate planes.

● A new babbitt metal for bearings subject to high pressures and temperatures has been developed by *Magnolia Metal Co.*, Elizabeth, N. J. This metal has a tensile strength of 17,500 lb. per sq. in., a yield point of 6,500 lb. per sq. in., a Brinell hardness of 27, and its pouring temperature ranges from 950 to 1,000 deg. F.

New Design for Large Cast Plates

Meehanite Research Inst. of America, Inc., Pittsburgh, reports that a new and unusual design for the production of large surface plates to be used in the as-cast



condition has been successfully developed by the *Fulton Foundry & Machine Co.*, Cleveland, Ohio.

The original problem was to equalize casting stresses in a plate 96 in. in diam., a size prohibiting normalizing, and at the same time obtain a permanent trueness after turning and grinding, since no other similar hand scraped plates were available for checking purposes.

The design is shown in the photograph. The spacing of the ribs was proportioned so that they are all of nearly uniform length, and the top was made comparatively thin so as to maintain a good proportion between the metal sections of the ribbing and the top.

Quenching Oil

E. F. Houghton & Co., Philadelphia, have announced a new quenching oil for a rapid quench, which is highly essential in the heat treatment of high explosive shells.

Included in its make-up is a chemical agent, it is claimed, which acts as a stabilizer and reduces oxidation or fractional distillation; also included is a synthetic wetting agent to provide rapid wetting-out properties, spreading a continuous film of oil speedily over the hot surface of the metal and preventing the formation of gas pockets.

Protective Metal Surface Coating

A new metal coating compound, designed for making repairs to damaged tin coating, has been developed by the *American Solder & Flux Co.*, Philadelphia.

The coating is said to be completely rust-resistant and will protect the underlying iron or steel to the same extent as hot-dipped zinc coating of the same thickness.

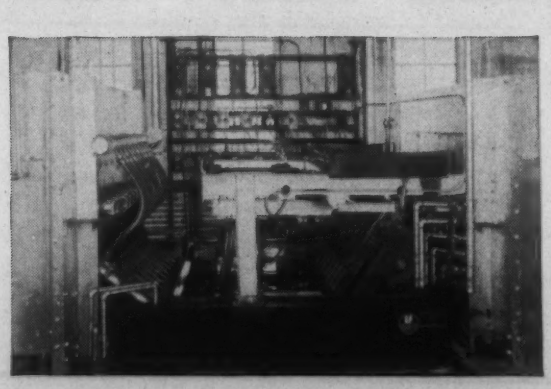
Since the melting point of the coating compound is lower than that of tin, the original coating is not melted or disturbed by the application, but joins with the undamaged areas of tin, forming a continuous and protective surface.

EF FURNACES

For Every Industrial Heat Treating Process

This Completely Automatic E F Furnace Equipment

Heat Treats Shells - - - Scale-Free



Continuous automatic quenching equipment. The shells are quenched without coming in contact with air, automatically reversed and charged into the tempering furnace at right.

The shell forgings are pushed thru the hardening and tempering furnaces in parallel rows, in protective atmosphere-filled conveying tubes. An automatic quenching equipment (shown at left) is located between the furnaces. The shells are quenched without coming in contact with air, automatically reversed and charged into the tempering furnace. This installation is gas-fired and is equipped with ten conveying tubes. A similar installation with 15 conveying tubes has also just been completed.

This is one of a number of installations we have made for the production heat treatment of shells and other defense products including machine gun clips, cartridge cases, aircraft and tank parts, gun and ammunition components, etc.

Send for printed matter showing this and other interesting installations. Submit your furnace problems to EF Engineers.

The Electric Furnace Co., Salem, Ohio

Gas Fired, Oil Fired and Electric Furnaces---For Any Process, Product or Production

World's Largest Forging Machine

The first of two huge forging machines, said to be the world's largest, is being installed at *Tube-Turns, Inc.*, Louisville, Ky. This mammoth equipment will be used in the production of airplane motor cylinder forgings and other armament needs.

The two forges are rated at 9 in. capacity; each machine weighs over 500,000 lbs. and requires over a year to build. The design is extremely compact, and because of this, according to the company, exacting accuracy, precision and speed in the forging work is assured.

Plating Zinc from Waste Materials

A new method of electroplating steel products with zinc, known as the Hubbell-Weisberg process, is being marketed by *Hanson-Van Winkle-Munning Co.*, Matawan, N. J.

The advantage of the process lies in its ability to use cheap sources of zinc instead of zinc anodes. The zinc is dissolved from galvanizer's skimmings, brass foundry fume, organic reduction residues, or ore; by a solution of ammonium chloride and ammonia. Insoluble graphite anodes are used in the plating tank.

Plating reduces the zinc content of the plating solution, which is then returned to the leaching plant where the zinc removed by plating is replaced.

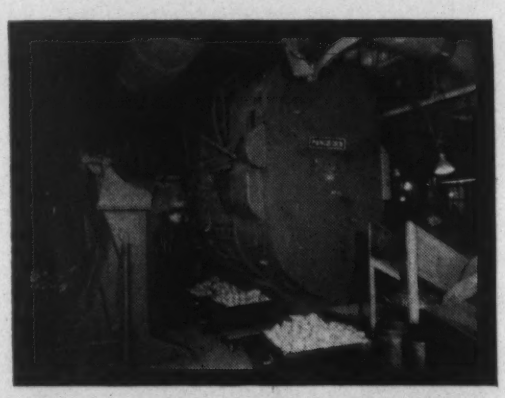
The process produces zinc coated wire or strip, which is said to be equal to that produced by other zinc plating methods. Steel handling, pickling and cleaning are the same as for other processes.

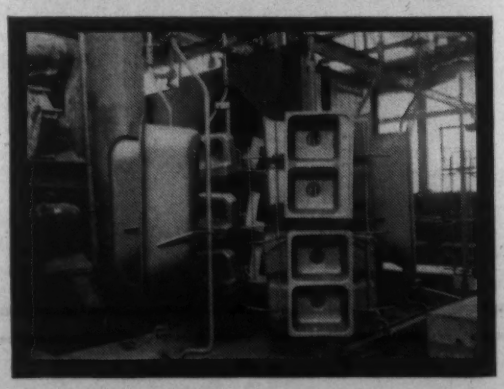
The plating tank has been specially designed to take advantage of the fact that anodes seldom have to be changed, and to provide covers that prevent the escape of ammonia fumes and at the same time permit easy re-threading of wires or strips.

The process works at high current densities and this fact combined with the high conductivity of the solution and the design of the electrical equipment, from generator to contactor, makes the process highly economical of electric power.

Say "ROTOBLAST" FOR BETTER, QUICKER RESULTS

"ROTOBLASTED" WORK ASSURES EASIER MACHINING, FINER FINISHES





"ROTOBLASTING" is the easy way to say airless blast cleaning. Many men in steel mills, forge shops, heat treating departments, etc., use "ROTOBLASTING" as an expression meaning a better way to produce bright smooth surfaces free from scale on work requiring machining, grinding, and other finishing operations.

SAVINGS

"ROTOBLASTING" has proven a surprising money saver in many ways. It has cut cleaning time and lowered cleaning costs as much as 50% in many applications. It is handling work three times as fast as former methods. It reduces labor requirements, lowers power costs, and increases production schedules as much as 200%.

ENGINEERING

Pangborn engineers are conveniently located to work with you or your representatives in making proposals to suit any of your blast cleaning and dust control requirements. These men are all specialists in these fields — and their many years of successful experience qualifies them to serve you to your most profitable interest. No obligation for consultation or suggestions, of course.

FOR NEW EQUIPMENT — OR FOR SUGGESTIONS ON HOW TO IMPROVE YOUR WORK —OR HOW TO LOWER YOUR PRESENT COSTS —"COME TO PANGBORN."

WORLD'S LARGEST MANUFACTURERS OF BLAST CLEANING AND DUST COLLECTING EQUIPMENT

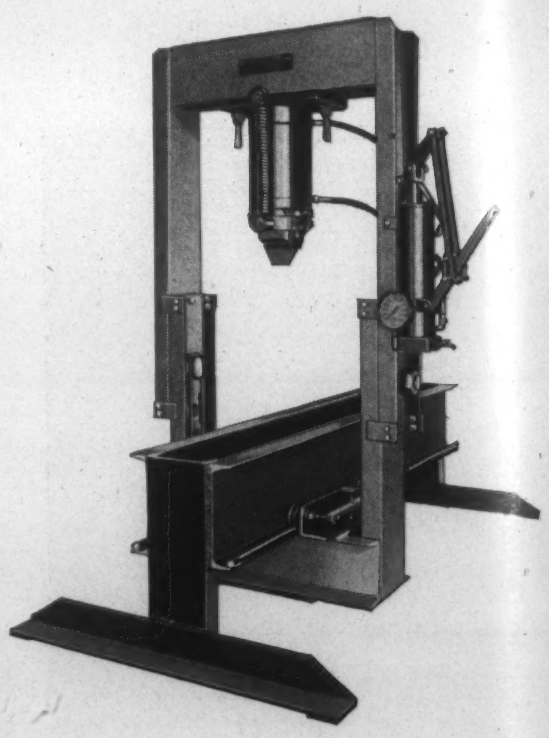
PANGBORN

PANGBORN CORPORATION • • HAGERSTOWN, MD.

● Designed specifically to reduce pick-up and increase resistance to mushrooming, 2 major problems in the spot welding of aluminum, a line of special electrodes is now available from *Progressive Welder Co.*, Detroit, Mich.

125-ton Press

A powerful 125-ton industrial hydraulic press mounted on a movable roller bearing carriage is now available, according to the *Bee-Line Co.*, Davenport, Iowa.



This press will meet practically all requirements where heavy pressing is necessary, and is said to be practical for every type shop. The jack carriage can be raised or lowered 16 in. with a minimum space between the ram and bed of 2 in., and a maximum space of 28 in. The ram travel is 10 in.

● Plastic hammers, developed for use in metal working trades, tool and die shops and many industrial applications, were recently introduced by *Rapid Mfg. Co.*, Glendale, Calif. They are widely used in place of leather mallets, or metal hammers, as any metal or plated surfaces can be struck a full blow without being marred.

Automatic Welding Gantry

The Cleveland Crane & Engineering Co., Wickliffe, Ohio, has designed, built and recently installed in their structural department a new automatic welding gantry for making long welds of 1-120 ft. continuously and automatically.

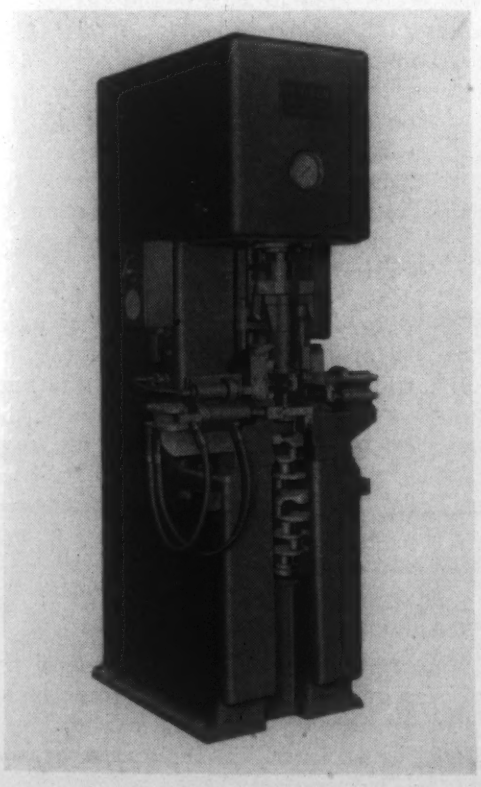
The machine can be traveled at any speed from 30 to 148 ft. per hr. to suit various size welds and materials. As the gantry travels, the welding rod is fed precisely and automatically to both sides of the work. In the welding heads, a tape is wrapped around the rod to shield the arcs.

By welding both sides of the work at the same time, the welding heat is distributed evenly, thereby neutralizing stresses and minimizing distortions that otherwise would take place, and thus produce straight accurate girders.

● To avoid burn-outs in roll neck bearings should safe bearing temperatures be exceeded, *Brown Instrument Co.*, Philadelphia, has announced the development of a protection system which detects the temperature of the bearings, records the temperature and gives an alarm if the safe bearing temperature is exceeded.

Assembly Press

A hydraulic press for assembling keys and timing gear on automobile crankshafts was recently built by *Denison Engineering Co.*, Columbus, Ohio.



This small-capacity hydraulic press is of 5-ton capacity and entirely automatic. The crankshaft is locked in place and the keys fed into the press through magazines. Four cylinders assemble the 2 keys and the timing gear is pressed into place by the ram.

A special safety feature halts the operation of the ram if the keys are not pressed into place properly. The equipment is also arranged so that if the timing gear does not fit, the pieces are rejected.

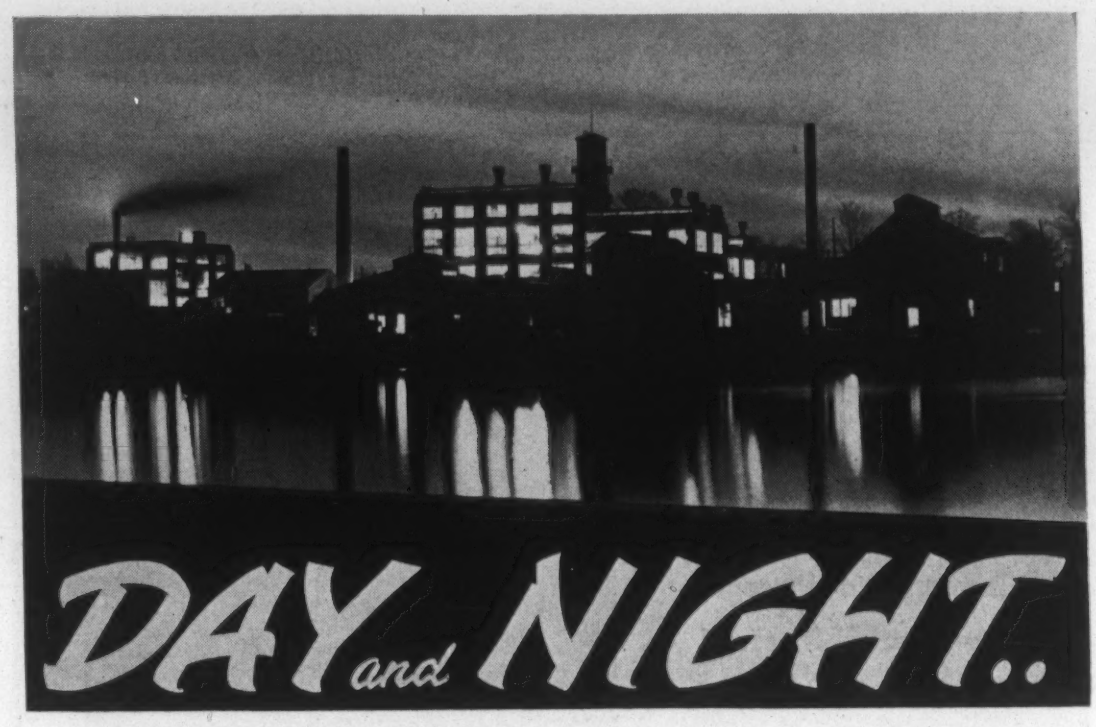
Foundry Oven and Low Temperature Furnace

Successful drying of molds or making of cores requires an even removal of moisture and vapors without overheating or skin drying. *The Gehnrich Corp.*, Long Island City, N. Y., has designed a foundry oven that is claimed to possess these necessary requirements.

A recent installation handles from 40 to 50 tons of molds. Heating of the large oven chamber is supplied from a direct gas-fired heating chamber located just outside the oven proper but built integrally with it.

A new conveyor-type, convection-heated, low-temperature, heat-treating furnace has also been developed by Gehnrich Corp., which can be used for a variety of heat-treating operations up to 1250 deg. F. on relatively small metal castings, slugs, stampings and forgings. It is said to provide continuous, relatively fast heat-treatment within close temperature limits.

● As a result of extensive tests, the *Alros Chemical Co.*, Providence, R. I., found that their blackening treatment on iron and steel resisted rust 50 hrs. and more in salt spray tests.



North American Radium is here being refined for the defense effort of the United States, Canada and Great Britain.

Improved production methods and new low rates now make Radium available to the Metal Industry as an economical medium for weld inspection and the detection of defects in castings.

Buy or lease your Radium from the only producer in the world!

Complete consulting Engineering service is available at all times.

Write for detailed information today

Specialists in INDUSTRIAL RADIOGRAPHY

CANADIAN RADIUM & URANIUM CORPORATION

630 FIFTH AVENUE Rockefeller Center NEW YORK, N. Y.

Hardening Saw Blades

A new electric salt bath furnace design by *Upton Electric Furnace Div.*, Detroit, Mich., was recently placed in operation for heat treating high speed saw blades of molybdenum and tungsten alloys. This furnace is used for the high heat hardening stage and is especially designed for hardening long broaches, knives, etc.

The pot, which is 30 in. deep and 18 x 12 in. at the top, is capable of handling up to 6,000 blades per day. It is heated internally by means of 2 electrodes placed diagonally and converging in such a way that the greater amount of heat is generated at the bottom of the pot.

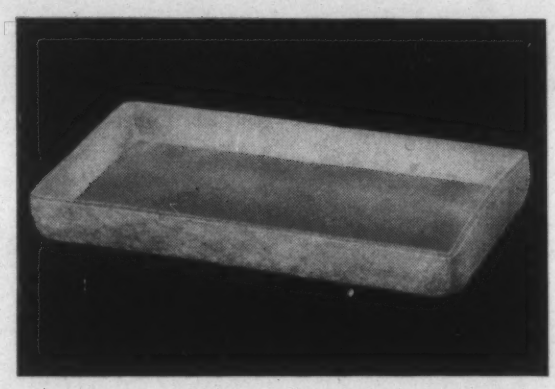
The resulting convection supplies sufficiently vigorous circulation of the heated salt so that the saw blades, which are up to 25½ in. in length and suspended in the pot, will be uniformly heated throughout their entire lengths. Approximately 30 batches of 20 blades each are currently being hardened per hr. at 2350 deg. F.

● *Keystone Carbon Co.*, St. Marys, Pa., announces that its line of negative temperature coefficient resistors are now available with metal coated ends for making electrical connection. The negative temperature coefficient resistors previously were supplied only with molded-in wires.

VITREOSIL (VITREOUS SILICA) INDUSTRIAL WARE

Crucibles Dishes Muffles
Pots Retorts Tanks Trays

Immune to Extreme Chemical, Thermal and Electrical Conditions



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Plants and Slants

To supply stock for the manufacture of forgings for airplane motors and fittings, and rod, bar and wire for national defense industries, the *Aluminum Company of America* plans to construct an additional blooming mill at their Massena, N. Y. works.

Taylor-Wharton Iron & Steel Co. have announced the completion of the Pittsburgh Lectromelt Furnace installation at their High Bridge, N. J., plant, which is now on a 100% electric steel-making basis.

Carboloy Co., Inc., Detroit, recently reported that over a 9 month's period their production of carbide tools for steel cutting soared 522% over the same period last year.

Revere Copper & Brass, Inc., is building a large new plant at Baltimore under the auspices of the Defense Plant Corp. to manufacture condenser tubes for the U. S. Navy and U. S. Maritime Commission.

Pittsburgh Metallurgical Co., Niagara Falls, N. Y., has started production of ferro-silicon at their Charleston, S. C., plant.

With the completion of the North Foundry, *Ampco Metal, Inc.*, Milwaukee, has expanded their production facilities again.

New Equipment for the Aircraft Industry

A high cycle extrusion milling machine, which, it is reported, effects a saving of 3½ days' production time per plane is now in use at the Lockheed Aircraft Corp. plant in Los Angeles. The machine, built by *Onsrud Machine Works*, Chicago, is the first of its kind to be used in the aircraft industry.

Also recently announced was a new 150-ampere direct-current arc welder by *General Electric Co.*, Schenectady, N. Y., for use in fabricating bright-surfaced, thin-gage metals, such as aircraft tubing. The chief feature of this welding machine is its high instantaneous recovery of voltage (40-60 volts).

● *Foxboro Co.*, Foxboro, Mass., has introduced a new model for applications involving control of temperature, pressure, liquid level or flow. The fundamental principles of operation, including the automatic reset of the control point, have been retained. The new features are principally refinements, for better appearance and still closer control.

Phosphorus Determinator

The concentration of phosphorus on the surfaces of the little air pockets or blowholes in iron or steel has recently been proved by using radioactive tracers, according to *Westinghouse Elec. & Mfg. Co.*, East Pittsburgh.

A simple "camera," consisting of a tin can, 2 small brass disks and a screw clamp, was improvised for this experiment. This device records on photographic film the rays from artificially radioactive tracers of phosphorus, revealing their location in the steel.

This method of taking pictures of radioactive tracers can be used to reveal the location of other substances besides phosphorus; for example, sulphur, carbon, manganese and silicon.

Meetings and Expositions

AMERICAN PHYSICAL SOCIETY, annual meeting. Princeton, N. J. Dec. 29-31, 1941.

SOCIETY OF AUTOMOTIVE ENGINEERS, annual meeting. Detroit, Mich. Jan. 12-16, 1942.

AMERICAN SOCIETY OF CIVIL ENGINEERS, annual meeting. New York, N. Y. Jan. 21-23, 1942.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS, winter meeting. New York, N. Y. Jan. 26-30, 1942.

AMERICAN SOCIETY OF HEATING & VENTILATING ENGINEERS, annual meeting. Philadelphia, Pa. Jan. 26-30, 1942.

INSTITUTE OF AERONAUTICAL SCIENCES, annual meeting. New York, N. Y. Jan. 28-30, 1942.

News of Metallurgical Engineers

R. Russell Fayeles, formerly with South Chester Tube Co., Chester, Pa., has become associated with Lukens Steel Co., Coatesville, Pa., as combustion engineer in the open-hearth department. . . . *Harold M. Lochrane* has recently joined the Kayden Engineering Corp., Muskegon, Mich., and will be in charge of methods and standards.

James P. Gill has been appointed to the Advisory Committee on Metals and Minerals to the National Academy of Science and National Research Council. He is chief metallurgist of the Vanadium Alloys Steel Co., Pittsburgh. . . . *Wm. E. Banford, Sr.* consulting engineer in the automatic screw machine products industry, was appointed production engineer for S. F. Bowser & Co., Inc., Fort Wayne, Ind.

James C. deHaver has been named to the technical staff at Battelle Memorial Institute, Columbus, Ohio, where he has been assigned to the division of foundry research.

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Replies to box numbers should be addressed care of METALS AND ALLOYS, *330 W. 42nd St., New York.*

HELP WANTED: Mechanical Draftsman. Young recent graduate wanted by responsible elevator manufacturer. Must be rapid, dependable and able to produce excellent work. Good salary and real future for right man. Give all details in reply. Box MA-31.

HELP WANTED: High Speed Steel Metallurgist to take charge of heat treating department of rapidly expanding small tool manufacturer. Steady business now employing about 300 offers exceptional opportunities. Metallurgist must be capable of directing research work in hardening small high speed tools. Age preferred 25-35. Starting salary $4,000 and bonus Location Middle West. Box MA-32.

Manganese Steel Welding Electrodes

For building up and reinforcing 11 to 14% manganese steel or carbon steels where high resistance to impact and abrasion is desired, *Harnischfeger Corp.,* Milwaukee, Wis., has introduced 2 new types of welding electrodes.

One is a coated manganese-molybdenum steel electrode on which the thin coating acts as an arc stabilizer and affords protection against loss of manganese and molybdenum. The other is a bare manganese-molybdenum electrode providing an austenitic deposit.

Both of these electrodes are applicable on such work as building up dipper lips and runners, hammer mill parts, dredge pump shells, rock crusher parts, railway frogs, road grading and mining equipment.

● Flexible steel bearings made by the *Harris Products Co.,* Cleveland, Ohio, are dried quickly and thoroughly by placing the bearings on a screen tray, which fits the top of the box-like affair. Air from a General Electric 5,000-watt forced convection unit heater is then blown into one end of the enclosing box, and passes up through the parts lying on the screen tray, quickly and effectively drying as many as 50,000 bearings per day.

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METALLURGICAL ENGINEERING

shop notes

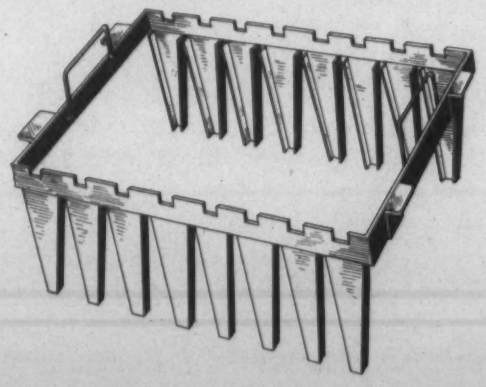
Radiographic Inspection Aids

by H. R. Clauser
Assistant Editor

In any industrial plant where radiographic inspection is part of the production line, it is highly essential that the X-ray department be well organized and efficiently run so that there will be no hold-up at that point in the line. Here are a few practical suggestions that might help facilitate the radiographic procedure. Many of them are already being used satisfactorily, and so it might be well to review them briefly.

Setting-up or positioning the radiographic equipment and the exposure time are the main time factors to be considered in taking the picture. Set-up time can be minimized by mounting the X-ray apparatus so that it is flexible, easily moved and positioned. The exposure time is, of course, controlled largely by the thickness of metal being examined and the radiographic equipment available. However, the selection of film and screens can do much to cut down on the exposure time. Wherever possible, intensifying screens should be used. With them, improvement in contrast and a decided reduction of exposure time can be obtained.

Several companies have recently developed high-speed film with which it is possible to reduce the exposure time almost one-half in some instances. Although the detail and definition obtained is not quite as sharp as on the slower industrial film, a sufficiently satisfactory picture is possible for a great many jobs.



There are various means of identifying the film in reference to its location on the object where it was taken. Lead figures are invariably used, and are held in place on the object while the picture is being taken either by means of adhesive tape or heavy grease. The grease method is probably the more rapid, but its sloppiness has caused many to use adhesive type. In a case where most of the identifying symbols and penetrameters are used over and over again for successive pictures, such as in radiographing a long weldment, the lead figures can be mounted on a very thin gage aluminum strip, and this strip moved along for each picture, thus eliminating the necessity of handling each symbol separately.

Lead-lined pass boxes, through which the exposed and unexposed film can be passed, located in the wall between the exposure room and dark room, speeds-up film handling considerably and saves a lot of shoe leather.

Dark room design and procedure must be carefully planned and operated to avoid congestion and a consequent slow-up in the radiographic inspection process.

There should be plenty of table space to load and unload cassettes. It is a good idea, where the screen cassette is used, to have an air line handy to blow out the cassettes each time before reloading. This will get rid of a lot of accumulated dust and lengthen the life of the cassettes.

Where films are being developed in large quantities, a good stunt is to use racks in which a number of hangers holding the film to be developed can be placed. These racks eliminate individual handling of each film hanger. The accompanying sketch gives a rough idea of a rack of this type, which has been designed by the General Electric X-ray Co. Using a rack of this kind, it is possible to handle as many as sixteen 4½ x 17 in. film at once.

Film developing time is governed by the kind of developer and the temperature at which it is used. There are now on the market several high speed developing solutions. One type will do a good job of developing in 3½ min. at 65 deg. F.

Drying the film is usually a problem because of the time and space required. If not carefully planned, this end of the department will be a serious constriction to efficient production. It is always a good idea to drain the film a few minutes before putting them into the drier. This gets rid of a lot of the excess water and speeds up the drying operation appreciably. Plenty of drier space with an ample, well-regulated supply of hot air is absolutely essential.

Blowholes in Large Bushings

by H. O. Jarvis
Niagara Falls Smelting Corp.

Sometimes difficulty is experienced in casting large bushings without having small blowholes appear on machining the inside diameter.

For example, in one case on record, bushings 15½ in. o.d. and 14 in. i.d. by 13 in. long were causing trouble. They were made with a green sand core and gated from the bottom. On the outside they machined perfectly, but on the inside small blowholes about ⅛ in. deep appeared after the first cuts were taken. The trouble in question is usually not encountered with smaller bushings.

This type of inside-surface defect is often caused by ramming the sand on the inside of the bushing too hard. It can be eliminated by ramming the mold more lightly and venting enough to allow the gas generated to escape after the material has entered the mold cavity.

Bushings of the general size given above are best cast in a vertical position with a sprue down one side parallel with the bushing and a runner from the sprue completely encircling the bushing at the bottom, with several small gates connecting the runner with the bushing on the outside diameter.

Two large risers should also be placed on top of such bushings, on opposite sides. They should be large enough to remain liquid until after the bushing has been set and act as feeders to feed the shrinkage that occurs as the casting cools.

Metallurgical Engineering Digest

FERROUS AND NON-FERROUS

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Materials for Sand Molds

A Composite

In all our discussions of molding sand and the properties of sand molds for foundry use, the separate constituents and their individual contribution to mold behavior should not be ignored. Both clay and silica flour, for example, need careful study as mold constituents.

Clay Substances

A general survey of available clay materials for molding sands is given by FRANK HUDSON ("British and American Clays," *Foundry Trade J.*, Vol. 65, Sept. 18, 1941, pp. 185-187). The following may be regarded as common constituents of clay: quartz, felspars, mica, iron pyrites, iron oxides, calcite, gypsum, dolomite, carbonaceous matter. Clays can be described as aggregates composed of a variety of mineral fragments ranging in size from sand grains to particles under one micron (0.00004 in.) in diam. As a class, the clay minerals are hydrated silicates of alumina, with or without the alkalies or alkaline earths.

Recent work on the constitution of American bonding clays indicates that kaolinite, beidellite, montmorillonite and a mineral resembling the sericite form of white mica are the most common clay minerals, and that the properties of the clay are different according to the type of minerals present.

For example, clays composed primarily of beidellite or montmorillonite have higher green-bond strength, and possibly better durability than others. This is of particular interest in view of the tendency toward synthetic sand productions using bentonite, inasmuch as this clay contains a high percentage of montmorillonite.

The water present in clay and clay-bonded materials exists in two ways. A certain amount is absorbed by the "clay cells" and is termed combined or "miscellian" water as distinct from the free moisture present, which can be removed on drying at 230° F. On heating above 1750° F., clay begins to lose its combined water, becomes "dead" and cannot usually be tempered.

Montmorillonite is dehydrated gradually up to about 1000° F., at which temperature crystallographic change begins. Kaolinite loses its water between 750° and 950° F., while the hydrated ferric oxides, collectively designated as limonitic material, lose practically all their moisture below 400° F. On heating clays above 1950° F., the mineral mullite ($3Al_2O_3 \cdot 2SiO_2$) is formed, together with one of the high-temperature forms of quartz.

Silica Flour

Much more important than a change in clay content and of equal importance to an identical change in moisture or bentonite is a change in silica flour addition, state H. W. DIETERT & GORDON CURTIS ("Silica Flour Controls Molding Sand," *Foundry*, Vol. 69, Sept. 1941, pp. 58-59; Oct. 1941, pp. 56-57). Care should be exercised in adding or controlling the amount of flour, since a fraction of a per cent will change both room and high temperature working properties of the sand.

Molding sand bonded with Southern bentonite possesses low sand setting properties. Thus, this type of sand favors silica flour additions.

Different batches of sand were prepared with silica flour varying from 0 to 20%. With increase of silica flour, moisture, green deformation, toughness, dry compression and density of the sand were increased. Permeability, green compression and flowability were decreased.

The sintering temperature increases with increase of silica flour. In the case of an increase in fines in sand, where the fines carry a large % of fluxing ingredients, sintering or refractoriness of the sand is decreased.

Silica flour additions to A. F. A. standard silica sand with 4.5% Western bentonite increased the values for moisture, green compression and deformation, toughness, dry compression and density. The refractoriness of the sand was also improved by silica flour. Contraction of the sand without the flour was 0.0125 in., while it is 0.0040 in. when 10% flour was added.

The hot strength of Western bentonite bonded sand may be held to a conservative value for various temperatures by avoiding working of the sand with a minimum of moisture. A hot strength of 7 lbs. at

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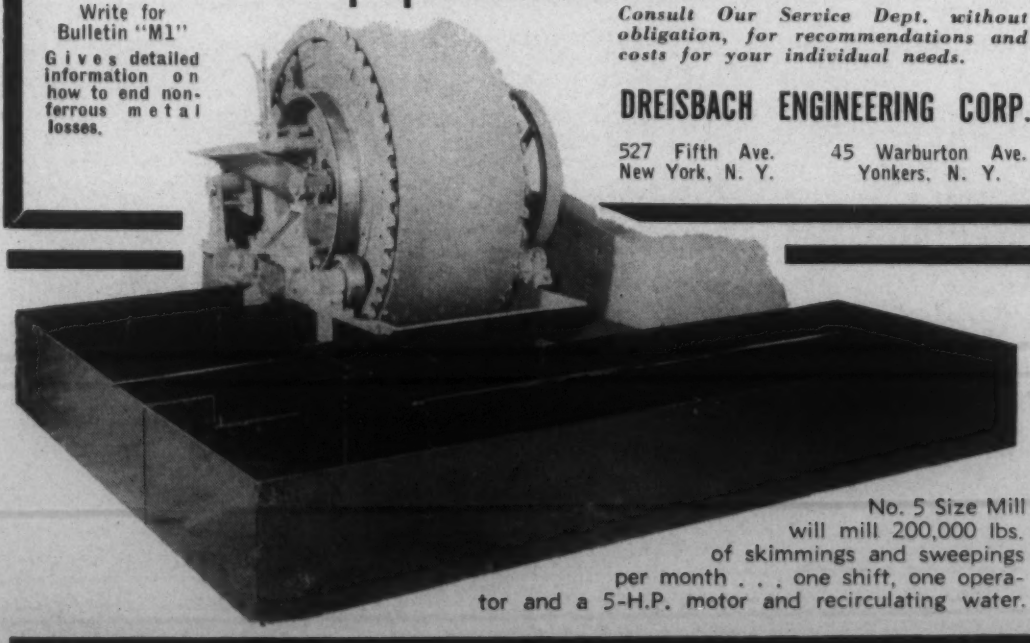

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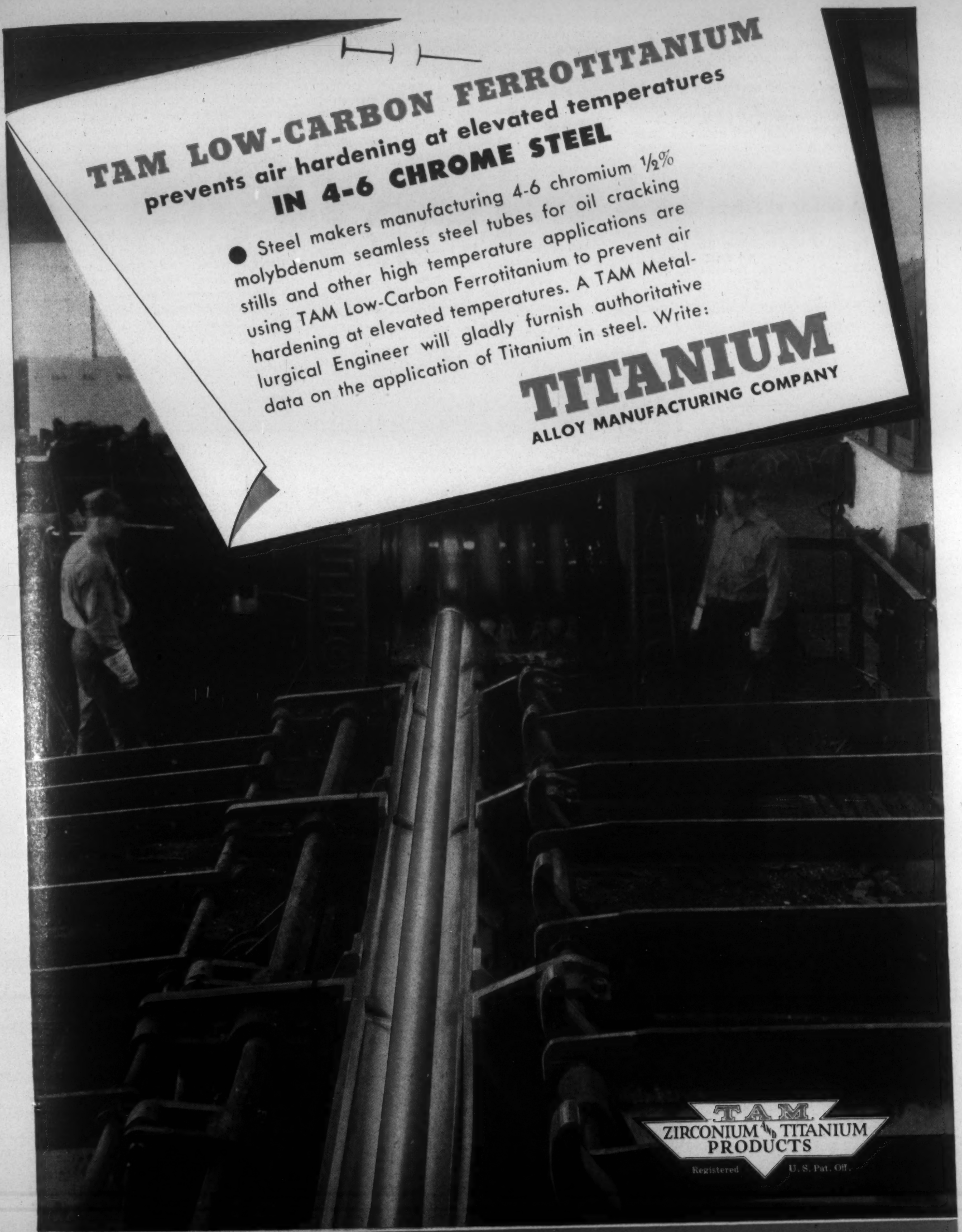

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2500° F. is satisfactory for both light and medium iron and steel castings. For large steel castings, a hot strength of about 10 lbs. is desirable.

Such values may be obtained with 1-2% flour addition. A 10% flour addition causes the hot strength at 2500° F. to increase to 40 lbs., which will hot-crack many steel and iron castings. X (1)

1a. Ferrous

Flame Cutting of Forging Billets

"Billet-Cutting for Steel Forging." H. E. Rockefeller (Linde Air Products Co.) *Am. Welding Soc.*, Paper, Oct., 1941 meeting. Descriptive.

Oxy-acetylene machine cutting offers an economical and practical means of speeding the cutting of billets to length for steel forging. Three general types of cutting machines are in use: (1) the straight-line Monitor-type machine, (2) the portable bar-cutting machine, especially designed for cutting individual rounds or squares, and (3) the multi-blowpipe bar-cutting machine, recently developed for the multiple cutting of rounds or squares.

The Monitor-type machine is extremely practical for cutting forgings and blanks, particularly small blanks and double-lengths used in the upset forging. Bars are lined up on a bed wide enough to accommodate 40 to 50 widths. The cutting machine travels on a movable bridge-type gantry that spans the width of the bed.

By heating the starting point on each bar with a welding blowpipe, ahead of the cutting action, the machine can make one continuous cut across an entire row of bars. Production of 100 to 110 blanks per hr. can be maintained from shift to shift when cutting 3-1/16-in. squares, and of 130 to 140 blanks per hr. when cutting 2⅜-in. rounds.

The portable bar-cutting machine (2) permits the automatic cutting of cold bar stock, either round or square, in sizes ranging from 2 to 15 in. The variations in blowpipe motion for the cutting of rounds on one hand or squares on the other are obtained by a simple adjustment of a blowpipe arm linkage mechanism. A self-contained power unit makes the machine entirely portable, and permits an infinite variation in speed between 1 and 75 in. per min.

The multi-blowpipe bar-cutting machine (3) provides the same advantageous blowpipe motion as the aforementioned portable bar-cutting machine, but is designed as a stationary installation and permits the use of as many as 5 blowpipes, operating simultaneously. A supplementary preheat for quick starting is furnished. With a suitable conveyor system for bringing bars to the machine, positioning them for the cut, and removing the cut blanks, an extremely high production rate can be obtained.

Oxy-acetylene machines are being used also for nicking shell forging blanks prior to mechanically breaking them for inspection. Recent investigations indicate that such blanks can be severed entirely by oxy-acetylene cutting, since the defects are readily visible on flame-cut surfaces.

All operations previously described have been made on cold material. The process also is applicable to materials at elevated temperatures for a number of important steel mill operations. Billets are cut to shipping length, forging slugs are cut for immediate processing, and individual shell blank ingots are sized while still hot.

In one Canadian plant, blanks for 9.2 in. shell forgings are cast in 12-in. square ingots with a dome bottom and sink-head top. These ingots are then trimmed automatically, at top and bottom, during the regular production cycle. FPP (1a)

Titanium in Steelmaking

"Modern Contributions of Titanium to Steel Production." Technical Staff, Titanium Alloy Mfg. Co. *Steel*, Vol. 109, Nov. 3, 1941, pp. 96, 110-111. Practical review.

Titanium is a considerably more effective deoxidizer than silicon, and is generally classed with aluminum as a "strong" deoxidizer. Strong deoxidation decreases segregation and tends to produce a finer grain size and improved yield strength, ductility, and impact resistance, but also results in lower hardenability, assuming heat treatment at the usual temperatures.

The general opinion is that the finer grain is due to the interference of some compound (oxide or nitride) of the deoxidizer with the normal growth of grains at high temperature. Aluminum is most used for producing fine-grained steel, but recently titanium has been substituted for part, or all, of the aluminum to an increasing extent.

The scarcity of aluminum is partly responsible for this; another reason is that steel treated with moderate amounts of titanium is clean, whereas aluminum-treated steel is likely to be dirty. Improvement in quality, and in yield of high-

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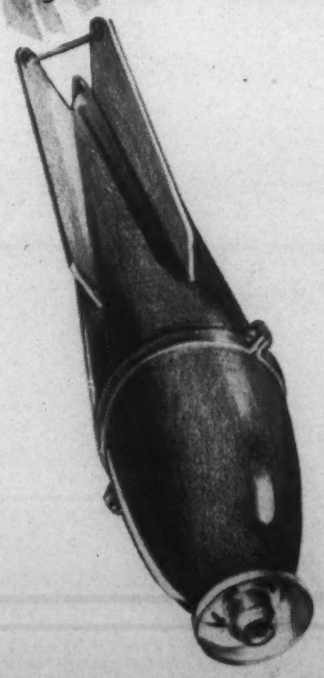

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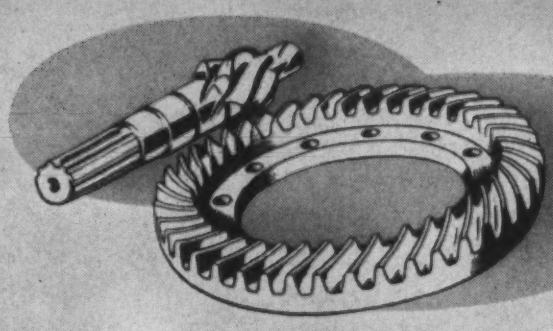
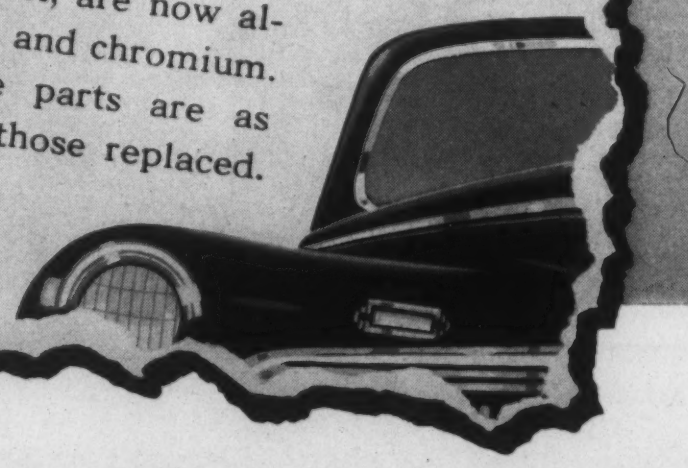


Molybdenum Replaces Nickel

Nickel is important not only in the finish of plated metal but in improving the toughness of steel. In defense production it is used in the manufacture of aviation engine parts and armor plate. Ford valves, transmission gears, shafts, and other parts formerly containing nickel, are now alloyed with molybdenum and chromium. For the purpose, these parts are as good as or better than those replaced.



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MCA

grade product, often more than justifies the slightly higher cost of titanium.

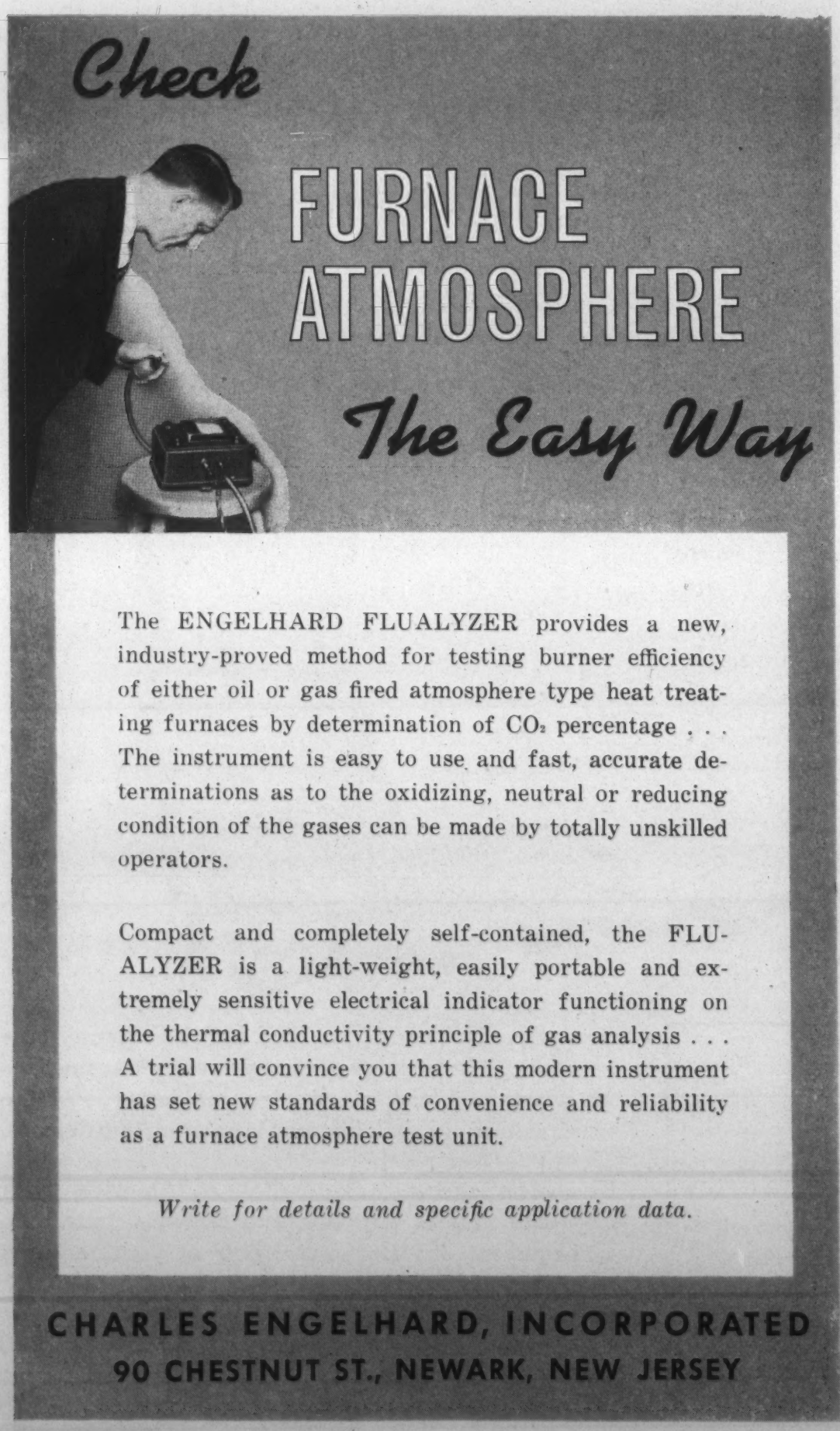
Titanium is used in the form of ferro-carbon-titanium. About 6-7 lbs. of ferro-carbon-titanium replace 1 lb. of aluminum. In some cases, where aluminum is entirely eliminated, as much as 12 lbs. of ferro-carbon-titanium are used instead of 1 lb. of aluminum for clean steel of the finest grain size. Where titanium is used only as a cleanser in steel that is otherwise deoxidized (with silicon or aluminum), 3-5 lbs. of ferro-carbon-titanium are generally added per net ton of steel.

Part of the ferro-carbon-titanium should be the last addition to the ladle. Occasionally, when aluminum is used with it for close control of grain size, some of the titanium may be added before some of the aluminum. More efficient and reliable utilization of aluminum may result, but probably at the cost of maximum cleanness. Titanium should always be added after the manganese and silicon.

Ferro-carbon-titanium is unsuitable for mold additions, as it does not dissolve or react quickly enough. When mold additions of titanium are nceessary, a low-carbon ferro-titanium should be used.

In making rimming steel, a small addition of ferro-carbon-titanium in the ladle saves some of the aluminum otherwise required, and improves the rimming action. A large percentage of all the titanium used in metallurgy is added to rimming steel.

To insure cleanness of high-grade alloy steels, titanium is often preferred to aluminum for deoxidation. As a degasifier to promote soundness, titanium often is superior, possibly because of its greater efficiency in eliminating nitrogen. Low-carbon ferro-titanium alloys containing 20-40% Ti, 3-20% Si and 3-8% Al are favored for such alloy steels because of their more rapid solution and higher rate of reaction as compared with the cheaper high-carbon alloys. Increasing amounts of titanium are used in this way in steels for light armor-plate, heat-resisting furnace parts, articles to resist acid corrosion, etc. MS (1a)



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Top Charging Open Hearths

"Top Charging Open Hearth Furnaces Is Economically Attractive." John O. Griggs (Otis Steel Co.) *Blast Furnace & Steel Plant*, Vol. 29, Sept., 1941, pp. 1002-1004. Discussion.

The advantages of the proposed method of charging open-hearth furnaces through the top by means of a drop-bottom box, handled by an overhead crane, are discussed.

Since no charging buggies or boxes would be used, the stock-house would need to be no more than half the size of scrap yards ordinarily used, as the large drop-bottom boxes could be loaded faster without the aid of stock straighteners. This would eliminate 80% of the stocking labor and save about 5c/ton of ingots. Two large drop-bottom boxes per furnace should be sufficient, thereby reducing rolling equipment about 90%.

All doors except one, which would be used for the hot metal spout and the working of heats with ore, lime, stone, etc., could be reduced to ⅓ their present size. Infiltration of air would thus be reduced and shut-downs for front-wall repairs, costing 2c/ton, would be eliminated. At least 75% of scrap conditioning will be eliminated, saving 75c/ton scrap consumed.

One machine will be ample for 12 furnaces, saving another 2c/ton. Furnaces can be charged uniformly, resulting in increased production and better quality steel. It will require not more than 1 min. to charge a large box of scrap through the roof, so that a panel should not be open more than 1-2 min. at a time.

No more than 6 boxes will be necessary for any class of scrap to charge a 150-ton furnace. The charging floor will be clear at all times and delays due to charging traffic will be eliminated.

The cost of equipping a 150-ton furnace for top charging would be about $20,000. Based only on a labor saving of 10c/ton, top charging will pay for itself in about 2 yrs. If the savings resulting from elimination of scrap conditioning is considered, it will pay for itself within 8 months or less.

Considering all aspects of the proposed method, a reduction in cost of 65c/ton of ingots can be expected. If top charging were adopted, steel now tied up in rolling equipment would furnish 150 tons of heavy melting scrap for each existing furnace. The scrap value would reduce the cost of equipping a furnace with top charging facilities about $3000. MS (1a)

Small-Cupola Practice

"Small Diameter Cupola Practice." William Pola. *Foundry Trade J.*, Vol. 65, Aug. 28, 1941, pp. 143, 144, 146; Sept. 4, 1941, pp. 155-157. Practical.

Small diameter cupolas are more critical in their operations than the large ones. Furnace lining, construction of the hearth bottom, coke, burning up the coke bed,

control of blast, tuyere dampers, charging, melting special charges, slagging, etc., are discussed.

A close-grained lining is better on the hearth walls because slag cannot penetrate it easily. Complete chipping out, and renewing the lining every two or three days, will keep the hearth in good order.

The average life of the bricks in the 24-in. cupola, melting high-steel-content mixtures, is 16 weeks. The average life of bricks in the balanced blast cupola, melting charges that contain no steel, is 20 weeks. Both cupolas run about 3½ hrs. daily. Failure to reduce blast when the cupola stack is emptying cuts out daubing and bricks.

Some cupolas have funnels or spouts fitted over the chute, used for ladle additions of chromium, silicon, nickel, etc. A simple funnel is better than hand feed for alloys. If the level of the chute is made slightly below that of the taphole, the metal will form a fan-like stream directly in front of the hole. Ladle additions dropped there from the funnel will be swept away into the ladle without fouling the bottom or sides of the chute. Additions put in the metal this way are well on the way to a molten state by the time the end of the chute is reached, and the stream action in the ladle stirs it thoroughly.

Sufficient limestone or some other form of flux should be used to make the slag fluid enough to run freely. Thick, very black slag is a sign of oxidation in most cases. The best slag color is a dark shade of green. When slag is thick, it tends to foul the coke surface, preventing carbon absorption and slowing melting rate through fouling the tuyere openings and upsetting the blast entry.

Coke bed height varies in different cupolas, depending on the class of castings made. Very light castings, such as piston rings, require a higher bed than that for ordinary jobbing work.

Because of trouble with early metal for rings, a plan was adopted to charge the first 5 charges at a 6:1 ratio, then 7:1 for the rest of the heat. When weighing wet coke, a few pounds extra should be allowed for water. Melting a special single charge is best done the fourth or fifth heat from the start.

An indication of good melting can be had by observing the gases at the charging door. A blue pinkish flame indicates good melting. A thick yellow flame usually means a build-up of charges in the stack. A definite red flame indicates melting too near the tuyeres or loss of bed. AIK (1a)

Electric Furnaces in the Foundry

"Electric Heat in the Foundry." ("Elektrowärme in der Giesserei"). F. Hassel. *Elektrowärme*, Vol. 11, May 1941, pp. 89-92. Review.

The various types of electric furnaces that are at present used for foundry purposes are classified in the Table.

Type	Capacity in tons	Connected load in KVA	Power consumption in KW Hrs. per ton of metal	Metal melted
Arc furnace	0.5	100	800	steel, cast steel, cast iron
	5	1500-2000	850	
	10	3000	800	
	15	4500-5000	750	
	30	7500-10000	700	
Coreless induction (high-frequency) furnace	0.5	300	750-850	alloy steels, possibly special cast irons
	1.0	500	700-800	
	6.0	1600	600-800	
Low-frequency induction furnace	0.5	270	600	special irons and cast iron in remelting and duplex processes
	1.0	350	550	
	2.0	500	500	
	3.0	600	cast iron chips 400	
Carbon (graphite) rod furnace	0.5	350	600-700 in continued operation. 700-800 in 10 hr. operation	special and cast iron in remelting and duplex processes
	2.0	900	600 in continued operation	

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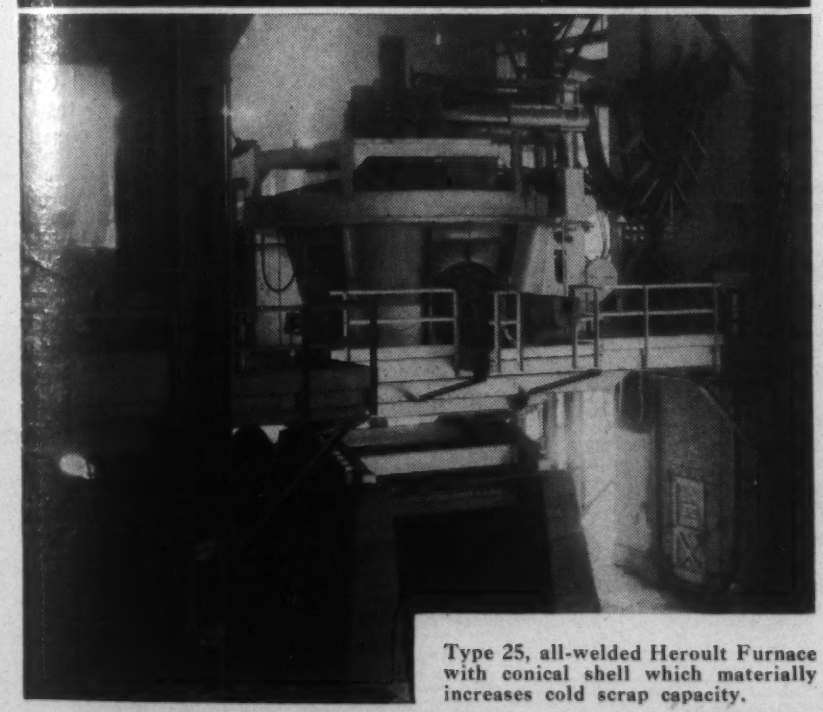

Type 25, all-welded Heroult Furnace with conical shell which materially increases cold scrap capacity.

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The last type (graphite rod furnace) has been developed in the last 3 years and is similar to the arc furnace, but has the advantage of lower carbon or graphite electrode consumption, and also behaves satisfactorily under discontinuous operation. Super-heating of melts up to 3100° F. is possible.

Such furnaces are built as single-phase units for small capacities, and as 3-phase furnaces up to 3 tons. Furnaces of 500 kg. and 250 KW connected load are in operation for melting briquetted cast iron, risers and scrap. Their power consumption is 800 kw.-hr. per ton of castings in 16 hr. operation, heating the melt to 2825° F.

Ha (1a)

1b. Non-Ferrous

Plaster Mold Castings

"Plaster Molds." W. A. Phair (Staff) *Iron Age*, Vol. 148, Oct. 9, 1941, pp. 74-78, 154-161. Descriptive.

A new method of producing non-ferrous castings, known as the "Capaco" plaster mold process, is used by Briggs Mfg. Co. This plant has been designed from the bottom up to use this process. The most notable features of the plaster mold process are unusual dimensional accuracy, faithful reproduction of fine details, and attractive as-cast surface.

Briefly, the procedure is as follows: The plaster is mixed with the other dry elements to give it strength and then mixed with water. The pattern impression is established in the mix when it is semi-set. This is followed by baking the mold after the pattern has been withdrawn. Plaster cores are inserted after baking, then the cope and drag are joined, and the casting is poured.

The plaster material must be permeable. The process makes use of a mixture with about 79% calcined calcium sulphate, 20% magnesium silicate and 1% of a substance to accelerate setting.

Voids in the mixture are created by adding water, and then drying out all the water. This creates a network of spaces for gas removal.

Gypsum plaster and silicate fiber are mixed dry. The water is purified and added to the plaster at the rate of about 180 parts of water to 100 parts of dry material. Then the mold is dried at 160° F. for 8 min., and moved to the extractor, where the mold is separated from the flask. Before water and plaster are added to the mold, all surfaces coming into contact with mold materials are sprayed with parting mixture to prevent sticking.

The mold is still somewhat soft when it leaves the extractor and is placed in the drying oven. The oven is divided into 2 heat zones—a high heat held at 1450° F., and a recalcining zone at 450°-500° F., tapering down toward room temperature at the exit end. In this process, drying without cracking of the mold can be done in 1½ hr.

After baking, the molds are inspected, cores and inserts added, and cope and drag mated. The pouring stand is different from the usual non-ferrous practice. The stand is a structural assembly mounted on 4 wheels and holds 12 molds. When the stand is in pouring position, hydraulic rams rise beneath each mold and, in addition to clamping the mold firmly, tilt the entire assembly about 5 degrees from the vertical.

An asbestos tube inserted in the gate hole serves as sprue. Castings are handled after shakeout in the usual manner except that no further cleaning is done and only a slight amount of trimming of gates is necessary. The surface finish is comparable to that of die castings.

The pattern and snap flask are one piece and are never separated. The combination is known as a die pattern, which is divided into 20 sections. The bottom plates of the pattern are of normalized Meehanite iron.

Design practice is to work with casting tolerances of ±0.002 in./linear in., and across parting lines, ±0.004 in. If the wall area does not exceed 2 in.,^{2} a thickness of 0.04 in. can be cast. A one-impression pattern will produce 32 pieces/8-hr. day.

Bulk of castings being turned out by this process are brass, but other types of alloys can be worked. VSP (1b)

Casting Non-ferrous Test Bars

"Making Non-ferrous Test Bars." N. K. B. Patch. *Foundry*, Vol. 69, Aug. 1941, pp. 65, 124-126; Sept. 1941, pp. 63, 141-143; Oct. 1941, pp. 53, 134-136. Practical.

Separately cast test bars may be standardized in shape, location of riser, method of gating, etc. so as to be representative of the metal. By the use of standard bars cast under controlled conditions, 2 castings chosen from 2 different heats should show about the same physical characteristics.

For compositions containing 80% or more of copper, the bars are cast so that half of the bar is in the drag and the other half in the cope, above which is the riser extending the entire length of the bar and

Modern Standards Demand

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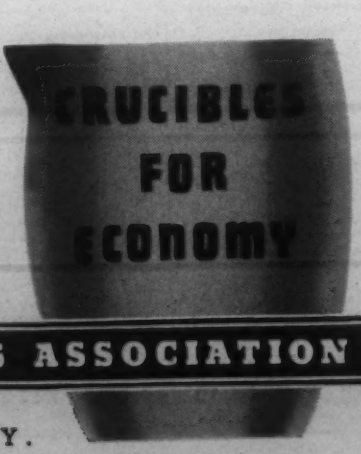
Tilting type oil fired furnaces using No. 225 Long Lipped crucibles, capacity each, 675 lbs. red brass. Foundry produces faucets & valves for the U. S. Army and Navy.
Photo courtesy Fisher Furnace Co.

● These five crucible furnaces recently installed, replaced antiquated melting equipment which was hard to control, undependable, wasteful of both fuel and metal and simply could not meet present day requirements.

For a minimum investment this foundry now has provided melting equipment having maximum economy, flexibility and reliability with metal quality assured.

IMPORTANT ANNOUNCEMENT: Copies of the booklet, "How to Cut Crucible Costs" are being mailed to all nonferrous foundries—3000 copies. The conscientious application of the instructions in this book will result in more heats per crucible.



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connected to the bar by a fin gate. The riser must also be slightly above level of the bar.

For the production of higher strength compositions, like aluminum bronze, silicon bronze, etc., government and other specifications recognize the need for a larger body of metal to act as feeder and prefer to have several bars cast or attached to the same riser. The bar must be sawed from the shrinkage head and machined to the desired size.

Another bar, known as the heel block bar, is received favorably. It is made up of a heavy shrink head on either side of which is cast a bar, which may be sawed off, and at the bottom of which is another bar to be sawed off for test. This type of bar has one advantage over the other bar in that there is no superheating of sand at any one side of any one bar.

In this test bar, there is sometimes some difference between the bar at the bottom beneath the riser as compared with the bar immediately attached to the base of riser. This is caused partly by superheated sand and partly by conditions arising from feeding one bar through the other, which in turn is influenced by temperature.

Cascading is likely to give trouble where the alloys being cast have a soapy or foam-forming ability, such as silicon and aluminum bronzes. In casting these alloys, the metal should enter at the lowest point through gates designed so there is no nozzle effect.

Often these bars are attached to castings. This is done by arranging the gates so that the same gate that leads to the casting leads also to the test bar. Test bars that are integral parts of castings are often specified for cast bronze and brass alloys in federal specifications.

For proper test results, at least 3 bars should be provided for any given heat. Federal specifications now operative for cast non-ferrous metals are sound and so workable that manufacturers of defense work will have little or no difficulty.

VSP (1b)

Making Calcium in the U. S. A.

"Calcium Metal Production, a New American Industry." A. B. Kinzel (Union Carbide & Carbon Res. Lab.) *Mining & Met.*, Vol. 22, Oct. 1941, pp. 488-490. Descriptive.

Calcium metal may be made in a number of ways; the Electro Metallurgical Co. uses the electrolytic process. Production of calcium chloride is difficult and entails accurate control. The problem is not so much the production of calcium in the cell, but rather the collection of the calcium. Calcium reacts readily at elevated temperatures with practically all the elements except the inert gases.

The need for close control is emphasized by the fact that the melting point of calcium, about 1490° F., is only 68° F. above the temperature of the molten calcium chloride. Calcium is deposited in molten state, but is collected in the solid state by continuous deposition and freezing on the cathode, the motion being adjusted so as to remove the calcium from bath at exactly the rate of its deposition.

The problem is complicated by the generation of chlorine at the anode and the need to keep it away from the cathode. Also, electrode effects increase the voltage, which increases the bath temperature, thus retarding the collection of calcium. Since small cells required constant attention, the company developed larger cells, which makes the process more economical.

Calcium metal is available in crude carrot or lump form. Carrots are from 7 to 14 in. in diam. and 7-25 in. long. Calcium metal in carrot form is of high purity, with iron and sodium present in amounts lower than found in calcium manufactured abroad. Small amounts of calcium chloride are entrapped.

The carrots may be remelted and cast in molds. The furnace used should be of such nature as to exclude oxygen- and nitrogen-bearing gases. Cast slabs weigh (a) about 50 lbs. and are about 2¼ x 16 x 24 in., or (b) about 1¼ lbs., measuring 3 x 8 in. and 1 in. thick.

When extremely pure calcium is required, cast calcium may be distilled in a high vacuum. In powdered form, calcium acts like magnesium. Calcium metal in bulk takes on a white coat of oxide, making it inert.

Broadly, calcium is used as a "deoxidizing," nucleation or precipitation agent for addition to non-ferrous metals. The use of calcium in magnesium is most common. Additions up to 0.25% result in improved surface with retention of refined grain condition and reduction of heat treating time. Calcium is introduced into magnesium by wrapping a small piece in an iron wire and plunging it under the surface.

Lead alloys for cable sheathing contain up to 0.25% calcium. However, calcium-lead alloys are made from calcium-lead hardener rather than from calcium metal.

In the steel industry, calcium is used for production of clean stainless steels as well as S.A.E. type steels with minimum of inclusion stringers. The present base price of calcium is $1.25/lb. VSP (1b)

2 Processing and Fabrication

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Rochelle Copper Plating

"Rochelle Copper Plating." A. Kenneth Graham & Harold J. Read. *Trans. Electrochem. Soc.*, Vol. 80, 1941; Preprint No. 10, 13 pp. Review.

The composition of the bath recommended is CuCN, 19-45 g./1.; NaCN, 26-53 g./1. (free NaCN is 3.8-7.5 g./1.); Na_2CO_3, 15-60 g./1.; Rochelle salt, 30-60 g./1. Additions of sodium sulphite, bisulphite or thiosulphite as brighteners are not recommended because sulphides are precipitated and cause rough deposits. Lead, added as sodium plumbite in amounts of 0.015 to 0.03 g./1., produces fine grain deposits which form a good base for bright nickel deposits.

A cathode current density of 2-6 amps./dm.^{2} is used, depending upon temperature and agitation. The anode area should be about twice the cathode area, and iron anodes equivalent to 5% of the total anode area should be used. The temperatures recommended are 120°-175° F. The higher the temperature, the higher are the anode and cathode efficiencies, but the decomposition of free cyanide is also accelerated.

The recommended pH of the bath is 12.2 to 12.8. At a higher pH the anode efficiency may be too low. The cathode current efficiency of the bath may vary from 30 to 70%, depending on the conditions, and the anode efficiency from 50 to 70%, when using the large anode area recommended. Agitation of the bath results in higher efficiencies and more uniform anode corrosion. AB (2)

Nickel Plating

"Nickel Plating." W. L. Pinner, G. Soderberg & E. M. Baker. *Trans. Electrochem. Soc.*, Vol. 80, 1941; Preprint No. 23, 30 pp. Comprehensive review.

Several different types of nickel baths are in use. The composition of any one may vary within wide limits. The double nickel salt bath contains: nickel ammonium sulfate, 105 g./1; ammonium chloride, 15 g./1. and boric acid, 15 g./1; pH, 5.3. It is not much used at present for plating, but a modification is used for electrotyping.

Zinc base die castings may be nickel-plated directly from a high sulphate bath or a zialite bath. The high sulphate bath contains: nickel sulphate, 105 g./1; sodium chloride, 27 g./1; boric acid, 69 g./1; sodium sulphate (10 H_2O), 330 g./1; pH, 5.6-5.8. Because of its limited current density range, difficulties occur in plating intricately shaped castings. Black streaks occur at low current densities and burnt deposits at high current densities.

The exact composition of the zialite bath is not given. It is an alkaline bath containing nickel pyrophosphates, citrates, free ammonia and sodium salts; pH, 7.5-9.0; current density 0.2 to 2.2 amps./dm.^{2} It covers the recesses of zinc objects more successfully than does the high sulphate bath.

The Watts type bath is one of the most important. A typical composition is: nickel sulphate, 240 g./1.; nickel chloride, 45 g./1.; boric acid, 30 g./1.; pH, 1.5-3.0 or 4.5-5.6. Pitting is more likely to be encountered in the intermediate range of pH, 3.0-4.5. The current density is 4.3 amps./dm.^{2} at 110° F.

More nickel is deposited from bright nickel baths than from all the other baths combined. These baths are a modified Watts bath, containing 2 types of addition agents. The first type of addition agent is usually a derivative of a sulphonic acid, which produces some grain refinement of the nickel and also permits higher concentrations of the second type of addition agent to be used. By themselves, the compounds of the second class (Zn or Cd, aldehydes, etc.) produce bright deposits, which are too brittle to be of value.

The earlier low purity (90-97% Ni), anodes have been displaced by the modern 99%+ anodes. The rolled depolarized anodes contain nickel oxide. The cast or rolled carbon nickel anodes on corrosion form a carbon silica film which retains loose nickel particles. In polishing steel before plating, the final operation should be done with a grease wheel. AB (2)

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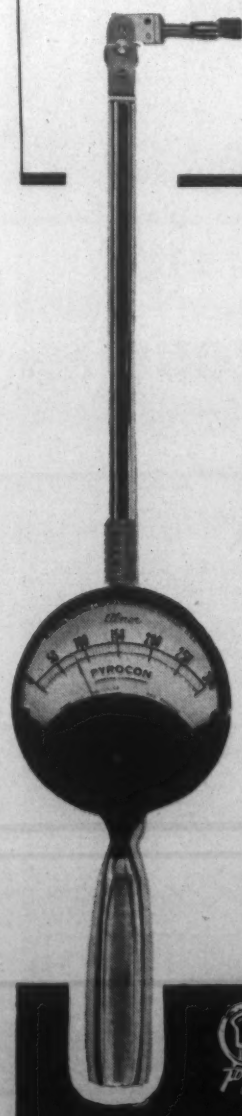

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Machining as Seen in Slow Motion

"Tools Seen in Slow Motion." L. T. Weller & E. M. Watson (Gen. Elec. Co.) *Am. Machinist*, Vol. 85, July 23, 1941, pp. 689-692. Descriptive.

High speed photography is now being used for studying the mechanics of machining. An Eastman Type II camera was used, and most accessories had to be improvised. The absence of interference from vibration effects is helpful. Cross hatching (1/32 in.) on the metal being cut shows the amount of distortion taking place during the machining.

The cross hatching indicates considerable crushing of the chip when steel is machined with a tool with a blunt rake. This crushing disappears and the chip rolls up when a greater rake is used.

Cast iron is broken off without distortion. If a heavy cut is taken, pieces may break away ahead of the tool.

In the case of brass, the chips are compressed at the bottom forming wedges, which cause the tool to spring forward and to move chips out faster than if the deflection of the tool were negligible.

JZB (2)

Improved Oxygen Cutting

"Divergent Nozzle Tips for Economical Oxygen Cutting." J. J. Crowe, G. M. Deming & J. K. Hamilton (Air Reduction Sales Co.) *Am. Welding Soc.*, Paper, Oct. 1941 meeting. Research

An investigation has been carried out to determine whether more economical oxygen cutting would result from the use of cutting tips fashioned with a divergent exit portion. A systematic analysis of the effect of the various design variables and detail test cuts has led to the development of a tentative series of divergent cutting tips for the range of material thickness up to about 8 in.

Using these tips, it is possible to reduce the cutting oxygen consumption 25-45%, as compared with standard forms of tips when operating at speeds previously used. It is also possible to operate at speeds 20-25% greater than those obtained with standard tips when using the same oxygen discharge rate employed with the standard tips.

These gains result from the narrow high velocity emerging oxygen stream and consequent narrow kerf which is 30-50% less than when standard tips are employed. The quality of cuts made with these tips is comparable with that obtained using the most precise of the standard tips.

Various new methods were employed for evaluating the stream characteristics with the result that the number of test cuts was materially reduced. FPP (2)

Silver Alloy Brazing

"The Best Joint Design for Silver Alloy Brazing." F. T. Van Syckel (Handy & Harman) *Welding J., N. Y.*, Vol. 20, Aug. 1941, pp. 527-532. Descriptive.

For either lap or butt joints proper clearances are of utmost importance in developing maximum strength. Optimum clearance for a butt joint in stainless steel was found to be about 0.0015 in. The lap joint for joining flat parts or tubular members is considered the most satisfactory since the lap area may be varied to any desired factor of safety.

The brazing alloys may be preplaced in making either flat or tubular joints, and can be used in the following forms: (1) inserts of sheet and flat washers, (2) rings of round or other shaped wire, (3) alloys may be sprayed on surfaces, (4) filed or powdered alloy can be sprinkled on, or mixed with flux and painted on the joint, (5) surfaces may be "tinned" with the brazing alloy by dipping or other methods.

For electrical connections, the high conductivity atttained represents a considerable improvement over former riveted or soft-solder sweated joint. For this type of joint, a sheet of alloy 0.010 in. thick is inserted between the copper conductors, put under pressure and heated. Flat and curved surfaces are brazed by the use of a circular washer of the brazing alloy.

Heating of the joint to flow the brazing alloy in place where pressure cannot be used may be done by oxyacetylene torch, or a gas-oxygen torch. Carbon resistance heaters have the advantage of rapid localized heat, and pressure can be applied simultaneously. Induction heating also provides a quick method of localized heating of joints, in which the alloy has been preplaced. Some brazing has been done in heated baths of fused salts, which have the advantage of fast, uniform heating with protection from oxidation.

A flux is required to clean off the joint surface and protect it from oxidation until the alloy flows into the joint. The flux also protects the brazing alloy from oxidation. WB (2)

2a. Ferrous

Weld Repair of Machined Castings

"Some Developments in the Repair by Welding of Finished-Machined Castings." Carlton G. Lutts & Paul Pfield. *J. Am. Soc. Naval Engrs.*, Vol. 53, Aug. 1941, pp. 491-501. Descriptive.

Castings with large areas of finish-machined surfaces, whose flatness and dimensions are required to be maintained within close limits, can be successfully repair welded. Castings up to 7 ft. in length and weighing 2 tons have been repaired with as much as 50 lbs. of weld metal added.

Radiographic inspection locates the defect in the casting, which is then excavated to remove the entire defective area down to sound metal. Consideration is given to the effect of the localized heating in producing localized or general distortion, and the procedure for minimizing the distortion is outlined.

Careful peening of the weld metal or of the casting itself is useful in control of distortion. Preheating to a minimum of 400° F. and stress relief heat treatment at 1100° to 1200° F. are considered mandatory for successful welding. Illustrations and sketches are supplied, which show the nature of the defects, extent of excavation, method of welding, and control of distortion. WB (2a)

Dies for Forging Shells

"Hot-Die Steels for Forging Shell." W. H. Wills (Allegheny Ludlum Steel Corp.) *Steel*, Vol. 109, Sept. 1, 1941, p. 62. Descriptive.

Steel for shell-piercing points on vertical presses contains 0.30% C, 9% W, 3% Cr and 0.50% V. The points are heat treated to a hardness of 38-40 Rockwell C, when used in the first press operation.

The treatment consists of preheating to

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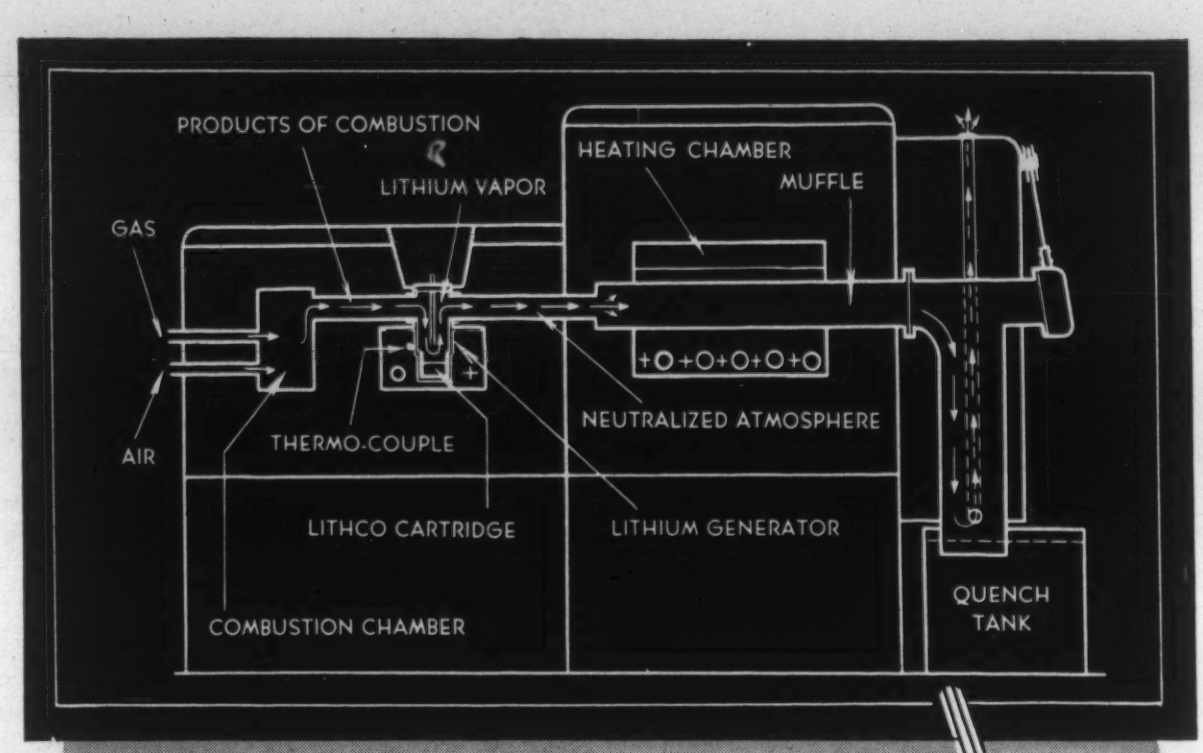

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1500° F., heating rapidly to 2150° F., cooling in air, and tempering at 1300° F. for 3-4 hrs. The furnace atmosphere is slightly reducing and this results in a tight, thin scale, which is allowed to remain on the punch when it goes into service. When properly broken in in service, a smooth, glazed, wear-resisting surface is produced.

Accumulation of lubricating mixture on points has much to do with the length of run obtained before redressing becomes necessary. The most suitable lubricant is a mixture of graphite and quenching oil. Sometimes powdered coal is added to the oil.

On 155-mm. shell blanks, at least 100 pierces can be made before redressing is required. Somewhat longer runs are obtained on smaller sizes.

In redressing, about 1/32 in. is removed from the nose contour. The points are annealed before redressing and again heat treated after dressing. When redressed so that they are below size, they can be turned down and used on a sizing press. Under certain conditions, points can be redressed 15-20 times before this becomes necessary.

The sizing operation is usually done on a horizontal press, with the piercing point supported by a sub-mandrel. The steel used for the sub-mandrel contains 0.30% C, 1.25% Si, 5% Cr and 1.5% Mo. Sub-mandrels are heat treated to 375 Brinell or 40 Rockwell C by preheating to 1400° F., heating rapidly to 1850°-1900° F., cooling in air, and tempering at 1200° F.

This steel is also very satisfactory when used for inserts and plungers on certain types of shell-forging machines. When used for these purposes, the plungers are hardened as above and tempered at 1150° F. to give a hardness of 41-43 Rockwell C. Inserts of gripper dies are left at 46-47 Rockwell C.

If an excessive amount of scale is put on this steel when hardened in an open fire, the material may be pack hardened in pitch coke at 1850° F. MS (2a)

Diffused Chromium Coatings

CORROSION PROTECTION BY CHROMIUM DIFFUSION ZONES ("Korrosionsschutz durch Chrom-Diffusionszonen") G. BECKER, K. DAEVES & F. STEINBERG. *Z. Ver. deut. Ing.*, Vol. 85, Feb. 1, 1941, pp. 127-129. Descriptive.

A new method of providing a protective coating on the surface of steel is described, which can be termed "inchromation." The process depends on diffusion between the steel and a chromium layer.

In order to embody one metal into another by diffusion, it is first necessary that the metal to be embodied must be soluble in the base metal in the solid state, and second that it is in a form that is easily absorbed by the surface.

These two conditions can be achieved by exposing the base metal (steel) to chromium chloride ($CrCl_2$), which reacts on the surface by forming (possibly) atomic chromium and iron chloride. The temperatures used should be only so high as to obtain sufficient depth of the inchromated zone, but without requiring too long a time.

If chromium chloride is employed as a solid powder under heat, the process is carried out in a furnace at 1850° F. for 5 hrs., which produces an inchromated zone of about 35% Cr at the surface, decreasing to about 13% Cr at 0.1 mm. penetration. In a liquid process, the parts are placed in a chromium-bearing salt bath and kept there at the desired temperature, or they are exposed directly to an atmosphere of chromium chloride vapor.

A scale-free surface is imperative for the success of the process. Best results were obtained with steels especially developed for inchromation (so-called "IK" steels). Inchromated parts have the surface properties of non-rusting steels, and are corrosion resistant and (up to 1500° F.) scale-resistant.

The consumption is about 200 g. Cr for 1 *sq. meter* surface. A particular advantage of the process is that it can be applied after the object has been fully machined or formed. Ha (2a)

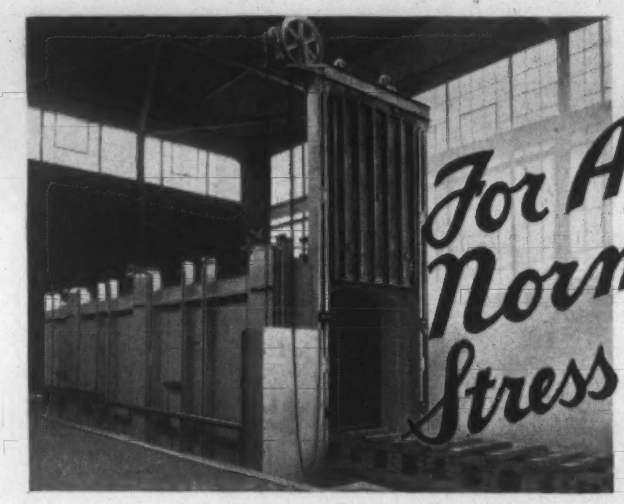
Aging Tools and Gages

"AGING TOOLS AND GAGES." W. P. BOYLE (Lindberg Engineering Co.) *Steel*, Vol. 109, Sept. 22, 1941, p. 71. Practical.

Gages should be "stabilized" so that when finish-ground to a given size at a given temperature, they will always be that size at that temperature. One of the most common methods is to grind gages to within a few thousandths of the required tolerance after they have been hardened and tempered at 350° F. for the desired length of time.

Sometimes grinding is not done until after aging. If much material is to be removed, it is always best to use a light final grind after aging.

Gages are aged by heating to 300° F. in a tempering furnace, cooling to room tem-



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perature, and then packing in dry ice to cool them to —105° F. This cycle is repeated 4-5 times, allowing the gage to come to room temperature each time between the dry ice and furnace treatments. Medium sized parts are exposed 4-5 hrs. to the dry ice.

In some cases, a better method of securing stabilized gages is to use an air-hardening steel with 1.5% C and 12.5% Cr. Parts are rough-machined, strain-relieved at 1200° F., finish-machined, hardened at 1850°-1875° F., air-cooled, drawn at 1000° F., rough-ground, drawn at 350° F. to remove grinding strains, and finish-ground. Secondary hardness obtained is 61-62 Rockwell C. The high-temperature draw completely stabilizes the steel.

While this steel is costlier and somewhat more difficult to machine than the more common tool steels, its wear resistance is very high, stabilizing treatment is simple, and parts made from it do not change shape in hardening. MS (2a)

Electric Salt Baths for Moly High Speed Steels

"Electric Salt Bath Furnaces for Heat Treating High Speed Molybdenum Steels." Howard Linn Edsall (Ajax Electric Co.) & T. E. Lloyd (Staff) *Iron Age*, Vol. 148, Oct. 2, 1941, pp. 39-46. Practical survey.

Salt compositions for heat treating molybdenum type high speed steels should be neutral chlorides, melting between 1830° and 1920° F.; the bath should be free from poisonous and obnoxious fumes at operating temperatures; the salt should wet the work and conduct heat uniformly and by contact; sludge formation should be low; the bath should not react chemically with the pot holding it; the salt should be water soluble, so the tools may be readily cleaned; it should remain neutral, without the necessity of rejuvenation; and salt should be cheap and readily available.

The advantages of electrically heated salt baths are that atmosphere is excluded and close control can be maintained of the temperature. Salt bath furnace pots are usually made of refractory shapes or cast heat resisting alloys. Metallic pots have a service life of between 1500 and 3000 hr., but newer ceramic types introduced by Ajax-Hultgren are reported to last 1 yr.

Heat treating temperature of molybdenum high speed steel is about 2230° F. The stages of hardening are: slow preheat to 1475°-1650° F.; rapid heat to hardening temperatures between 2230° and 2300° F.; rapid cool or quench; and subsequent temper or draw at temperatures up to 1100° F.

Immersed electrode salt baths eliminate the necessity of warming the tool before preheating, since the heat is transferred from the liquid salt to the steel more quickly and uniformly. The film of salt on tool also acts as a blanket, preventing too rapid heat transfer.

The quenching temperature rarely exceeds 2280° F., depending on the steel analysis. Overheating, in addition to its effect on grain size, has other ill effects. Salt baths eliminate exterior oxidizing influences, and their uniformity precludes local overheating.

Quenching may be done in air but salt quenching is claimed to give better results. Tempering for 30 min. to 2 hrs. at 1000°-1100° F. develops maximum hardness. Temper heating must be slow. VSP (2a)

Electrodeposition of Iron

"Iron Deposition." C. T. Thomas (U. S. Bur. Engraving & Printing) *Trans. Electrochem. Soc.*, Vol. 80, 1941, Preprint No. 15, 8 pp. Review.

Iron *plating* has only a limited application. The electroforming and electrowinning of iron have been of more interest because of the useful physical properties of iron. It can be deposited hard and brittle, or rendered soft and malleable by heat treatment.

The first use of electro-deposited iron was as a facing on printing surfaces to improve wearing quality. [*Because of the present shortage of nickel, this use of iron may again become of importance.*—A.B.] In 1868 iron electrotypes were used in Russia to print bank-notes.

Attempts have been made to electroform iron sheets and tubes, but these projects, after operating for a while, have been abandoned for economic reasons. Iron plating may be used for building up worn or over machined parts, but for this use, it has competition from nickel and chromium plating. A pulverized electrolytic iron was at one time used for cores of induction coils, and at present electrolytic iron powder is used in powder metallurgy.

Since 1930, the U. S. Bureau of Engraving and Printing has used iron deposition in preparing plates for printing government currency. A nickel face is first deposited, and then backed up with a heavy iron deposit.

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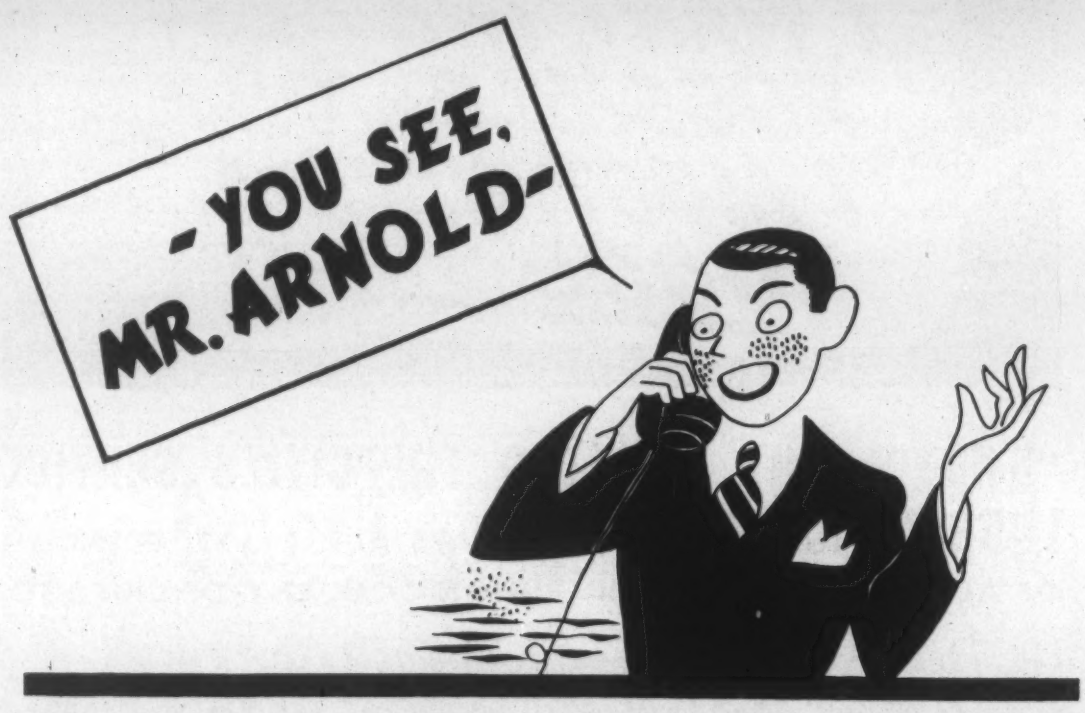
The U. S. Rubber Co. has done work on the electroforming of molds for rubber, glass and plastics, [See METALS AND ALLOYS, Vol. 10, Nov. 1939, p. MA 636.] Two types of bath are used: a ferrous ammonium sulphate bath and a ferrous chloride bath. A typical sulphate bath contains 350 g./1. of ferrous ammonium sulfate, and is 0.01-0.02 *N* in sulphuric acid. Operating conditions are: 7 amps./dm.^{2} at 140° F. At room temperature the acidity of the bath is kept at 0.005 *N* and a current density of 2 amps./dm.^{2} is used.

The chloride bath contains 400-500 g./l. of $FeCl_2 . 4H_2O$, and is about 0.01 *N* in hydrochloric acid. It is operated at 190° F., with a current density of 6 amps./dm.^{2} At higher temperatures 30 amps./dm.^{2} can be used.

Both baths should be practically free of ferric iron. Anodes of high purity iron are best, although steel and cast iron have also been used. Anode bags may be made of blue African asbestos, woven glass, or synthetic textile fibres. The tanks are best made of rubber-coated steel, lined with acid proof brick.

The Brinell hardness of electrodeposited iron may vary from 130 to 360. For soft deposits the tensile strength is around 56,000 lb./in.^{2}, and the elongation about 20%. For hard deposits the tensile strength may be 113,000 lb./in^2 and the elongation 0%.

On annealing at 1650° F., the mechanical properties approach those of open hearth ingot iron, with a Brinell hardness of about 90, a tensile strength of about 40,000 lbs./in.^{2} and an elongation of 30-40%. AB (2a)



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Weld-Cracking Under Stress

"WELDABILITY—CRACKS AND BRITTLENESS UNDER EXTERNAL LOAD. PART I-TYPES OF CRACKS AND DEFINITIONS OF WELDABILITY. A REVIEW OF THE LITERATURE TO JULY 1, 1939." W. SPRAGEN & G. E. CLAUSSEN. *Welding J., N. Y.*, Vol. 20, Aug. 1941, pp. 329s-347s. Correlated abstract. [For work on cracking in the absence of external stress, see METALS AND ALLOYS, Vol. 14, Aug.. 1941, p. 218.]

The possible causes of cracking of welds under external load are indicated as hard zones, shrinkage stresses, multi-axial stress plus hard zones, stress concentration, as-welded cracks, coarse grain, strain aging, defective welds, defective base metal and other miscellaneous causes. Stress relief heat treatment may be effective in reducing the tendency to crack, because it achieves relief of residual stress, enhanced ductility and occasional reduction in hardness.

The increased tendency toward cracking in higher carbon or higher alloy steels is discussed, and relief from the defect shown to accompany preheating or other special treatment before, during or after welding. Brittle failure is a characteristic of fractures caused by external loads, and they are not confined to the heat-affected zone.

The high incidence of cracks in non-stress-relieved welds indicates that shrinkage stresses may be the chief cause. Where the external load is dynamic, and fatigue is a factor, any defects such as slag, oxide inclusions, shrinkage, cavities, poor fusion, blow holes or poor geometry of weld reinforcing may cause cracking of a brittle nature.

A discussion of the failure of various European welded bridges indicates that such failures can be averted by rigid inspection of steel, and proper sequence of welding to reduce the residual stress. The presence of laminations may cause cracks to start in the base metal or cause their rapid propagation where they enter a laminated region. The nick break test on unwelded steel is sometimes employed for detecting laminations.

Where the composition of the steel or the cooling rate is favorable for martensite formation in the heat-affected zone, the martensitic, brittle structure is the chief cause of cracking. Coarse grain, especially of Widmanstaetten structure, favors cracking, and the cracks usually pass through the ferrite boundary, because of impurities collected at the boundary, and also because of the lower strength of ferrite. McQuaid-Ehn grain size is believed to be of minor influence on cracking of steels containing up to 0.52% C.

Numerous definitions of weldability are presented, concerning which the authors comment that there is no standard or accepted definition, and it appears that there is more than one ideal weld. Some of the definitions are "all inclusive," others are restricted to the base metal, but the basis for the various expressions is the extent to which the properties of the weld, the heat affected zone, or the joint as a whole, depart from the properties of the base metal.

Heterogeneity is always present, owing to the presence of both "cast" and "wrought" metal in the joint. The type of service may cause differences to appear in the expression of the extent to which the weld properties depart from those of the unwelded base.

Hardness is one criterion of a dangerous heat affected zone, on the supposition that high hardness is indicative of a brittle structure. Hardness and toughness together are considered by many to be necessary in an expression of weldability to determine the degree of weldability of different steels where hardness levels are the same after welding.

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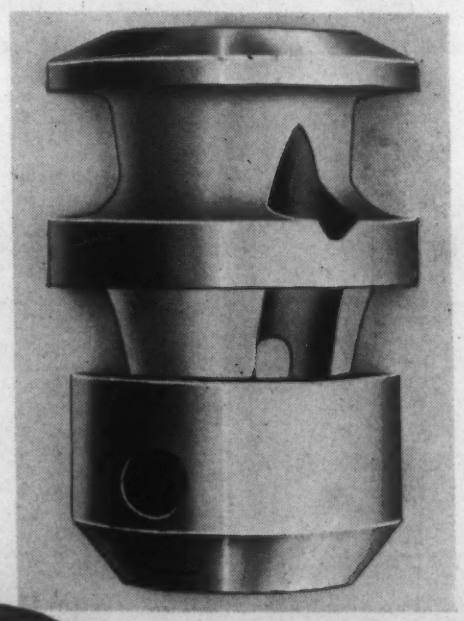

Irregular shape of chuck body caused serious distortion with former hardening process which heated whole front end. TOCCO heats up and hardens only the nose and wrench holes, the wearing areas. Eliminates distortion and rejects. Courtesy of The Jacobs Manufacturing Co., Hartford, Conn.

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The necessity for preheat to reduce hardness, or the degree of preheat required to give standard physical properties for a welded joint, are other forms of the definition of weldability applied to high tensile steels. Chemical specifications are considered by a few to be sufficient to define limits of weldability. WB (2a)

Continuous Welded Rail

"Seven Years of Continuous Welded Rail on the Delaware & Hudson." P. O. Ferris. *Railway Age*, Vol. 3, Aug., 24, 1941, pp. 312-316. Descriptive survey.

Seven years of observation of continuous welded rail vs. jointed track construction have given results that, although not conclusive, are indicative of what may be expected of welded rail as compared with jointed rail.

Two test sections were established. One section in the vicinity of Schenectady, N. Y., comprises 11.2 miles of 131-lb. welded construction and 11.2 miles of 130-lb. jointed construction with identical fastenings and stone ballast. The other, near Port Henry, N. Y., has 7.9 miles of welded track and 17 miles of jointed construction with identical fastenings and cinder ballast. Careful records are kept of the maintenance expenditures on each test section.

From the data available over the past 7 yrs., it was found that maintenance costs are cut appreciably on continuous welded rail as compared to the jointed type construction. On the Port Henry section, the man-hrs. per track mile per million gross tons per yr. for the jointed track was 25.71 as compared to 19.75 for the welded construction. This gives a per cent reduction in maintenance for welded rail of 23%.

At Schenectady, 36.28 man-hrs. per track mile per million gross tons a yr. were required on the jointed track and 22.08 on the welded rail. This is a 39% reduction in maintenance for the welded construction.

Of the 10,984 welded joints, there have been only 29 failures. Twenty-five occurred in thermit welds and 4 in flash welds. The failures in the thermit welds have been attributed to improper design and lack of accurate control of the preheating temperature, improper welding technique, defects already present in the rail at the time of welding, and the use of an improper type of thermit.

The failures in the flash welds were caused by the presence of zinc in the weld, burned spots on the edge of the rail base, and defects present in the rail at the time of welding.

The larger number of failures in the thermit welds was due to the fact that this type joint was used in the pioneering work on an experimental basis. Since the first installations most of the causes of failure in the thermit welded joint have been eliminated.

There are many advantages in favor of indefinitely long rails, some of which may be listed as follows:

(1) Lower cost of track maintenance.
(2) Longer life of the rail and consequent saving in rail-laying expense.
(3) Better conductivity in track circuits and elimination of the necessity of bonding joints.
(4) Smoother riding track.

There are several disadvantages as follows:

(1) Necessity of removing all rails in a given heat if an excessive number of transverse fissures should develop in that heat.
(2) Necessity of removing broken and defective rails.
(3) Problems presented in the handling of continuous rail that has been released. Thus far, none of these disadvantages has been actually encountered in practice.

HRC (2a)

Flake Formation and Annealing

Flake Formation and Embrittlement by Hydrogen Absorption of Steel in Annealing ("Flockenbildung und Versprödung durch Wasserstoffaufnahme des Stahles beim Glühen") E. Houdremont & H. Schrader. *Tech. Mitt. Krupp, Forschungsber.*, Vol. 4, May, 1941, pp. 67-98. Review plus research.

A survey of the literature on this subject gives as causes for the occurrence of flake cracks: (1) Stresses, caused by temperature differences in cooling, by deformation, and by transformation; and (2) metallurgical factors, such as impurities, segregations and gases. Neither of these two causes alone can be held responsible, however, for there seems always to be a common effect of both. New experiments were made and are described in full.

One thing that was established with certainty was that with increased cooling velocity the number of flake cracks increases, and the combination of even low hydrogen contents and higher cooling velocities suffices to cause the formation of flake cracks. In a material that is free of hydrogen, stresses alone cannot produce flakes. On the other hand, in a hydrogen-containing steel, stresses can substantially influence the orientation of the flakes and even cause flake formation in such cases where the hydrogen content alone is not sufficient

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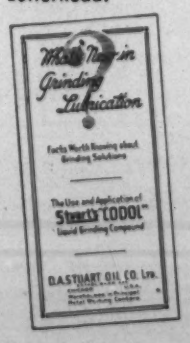

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to cause it at a definite cooling velocity.

The formation of martensite during heat treatment increases the tendency to flake-formation because the gamma-alpha transformation is shifted to lower temperatures and the reduced permeability does not let enough hydrogen escape to reduce its content below the critical amount at that temperature.

Industrial steel production employs annealing temperatures and annealing times which may readily lead to harmful hydrogen absorption. Sulphidic inclusions do not change hydrogen absorption very much and, therefore, do not affect the tendency to flake-crack formation.

Oxygen inclusions, however, which often contain hydrogen in combined form, can increase the tendency to flake-crack, for at high annealing temperatures the inclusions are decomposed and hydrogen is liberated; this is particularly likely if hydrogen is also absorbed from the annealing atmosphere. Segregations behave, with respect to hydrogen absorption, exactly like the surrounding material. Hydrogen can also be absorbed from hydrogen containing gases, water vapor and even from carburizing compounds.

The absorption of hydrogen in solid steel occurs in annealing in hydrogen and causes embrittlement, which leads to decrease of elongation and reduction of area. This deterioration is primarily associated with the formation of fine interior cracks appearing in the tensile test close to the fracture. The amount of hydrogen required for *this* defect is much lower than that necessary for flake formation.

Austenitic chromium-nickel steels are less sensitive although longer annealing times in hydrogen-containing gases and especially increased pressure reduce this relative insensitivity. The absorbed hydrogen can be removed in plain carbon and low alloy steels by tempering at low temperatures (200°-400° F.), but higher alloyed (austenitic) steels require from 900°-1100° F. to drive off the hydrogen.

The behavior of hydrogen-containing steels at low temperatures (down to —110° F.) depends on the amount of hydrogen absorbed. Low hydrogen contents give greater embrittlement with decreasing temperature. If the hydrogen content is high, cooling to low temperatures causes hydrogen to escape, which at first results in a recovery of elongation and reduction of area; the improvement, however, disappears again on further lowering of the temperature. The escape of hydrogen takes place easier in unalloyed steel than in chromium-nickel steel. Ha (2a)

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The reasons for this phenomenal acceptance can be summed up in one short sentence: SIL-FOS and EASY-FLO enable manufacturers to get fast production of high strength, permanently reliable gas-tight joints—at surprisingly low cost per joint!

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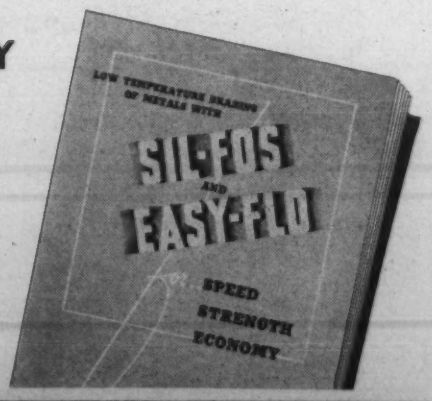
The reasons why SIL-FOS and EASY-FLO consistently make strong, reliable joints in fast time at low cost are given in detail in this newly published Bulletin. The numerous illustrations of actual jobs are full of ideas that may help you speed up brazing production, get better joints, reduce costs. Write for a copy of Bulletin 12 today.



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2b. Non-Ferrous

Welding Aluminum

A Composite

So much aluminum (once an "unweldable" metal) is being welded today and so many people are writing good descriptions of the operation that it is nearly impossible for the busy engineer to note all the developments as fast as they occur. The subject, however, is of such obvious importance at present that we've endeavored to summarize below the contents of some very recently published articles on spot welding and gas welding of aluminum and its alloys.

Spot Welding

The aluminum alloy spot welding process provides the engineer with a new and valuable method of attaching metal parts together. Not only are spot welds exceptionally strong and inexpensive to make, but their extremely smooth surface appearance in this age of high speed airplanes makes possible decreased aerodynamic drag without the extra expense of flush-type rivets or screws, states P. H. MERRIMAN of Glenn L. Martin Co. ("Aluminum Alloy Resistance Spotwelding," *Am. Welding Soc.*, Paper, Oct. 1941 meeting).

Owing to the critical metallurgical properties of the aluminum alloys, however, and particularly their narrow plastic range and high electrical conductivity, the methods and equipment applicable to steel were hopelessly inadequate when applied to the lighter alloys. It was realized early in the investigation of the process that, not only would exceptionally high currents be required, but the magnitude and duration of the weld current must be held to within limits that were impossible to maintain on a production basis.

The magnitudes of welding current required for aluminum alloys are beyond the layman's comprehension. For a representative thickness of aluminum alloy used in aircraft construction, 25,000 amps. are required; and this current flows for a period of only 1/10 sec. Only the very smallest variation from these figures is allowable in order to produce welds of acceptable physical and metallurgical quality. For example, a difference of 500 amps. or

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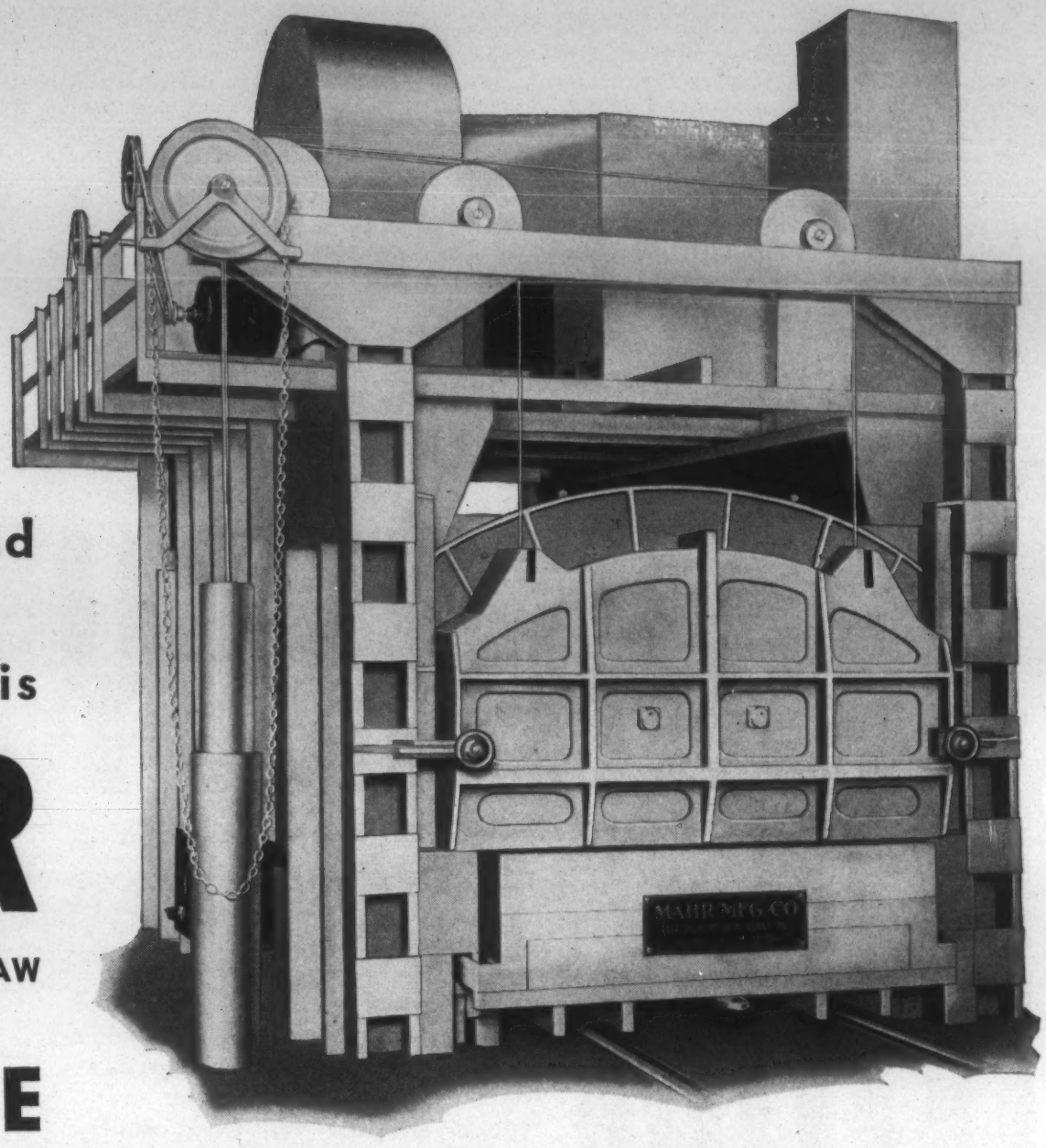

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of 1/100 sec. may seriously affect the quality of the weld.

In order to put aluminum alloy spot welding on a production basis, it is necessary that all variables encountered in the process be automatically maintained once they are set so that it is merely necessary for the operator to set a few dials according to predetermined settings and to operate a button to produce welds. The most important factor, however, in realizing the maximum possibilities and production economies of the process lies with the man who designs parts for spot welding. In his hands rests the answer as to whether or not a given part is economical to spot weld.

American engineers should find of great value a correlated abstract on spot welding of light alloys prepared by R. F. TYLECOTE ("The Spot Welding of Light Alloys—A Review of Published Information," *Trans. Inst. Welding, London*, Vol. 4. Apr. 1941, pp. 56-75). Many tabular data and illustrations of weld design are included. Among the topics covered are just about all possible factors—weldability, specifications, equipment, processing, properties, electrode materials, heat treatment, metallurgical structures, electrical conditions, etc.

Some interesting and practical tips on spot welding aluminum alloys are presented in a discussion of their amenability to the process, by C. L. HIBERT ("The Spotweldability of Aluminum Alloys," *Welding J., N. Y.*, Vol. 20, Aug. 1941, pp. 497-504). The newer energy-storage systems are of particular utility for aluminum alloys.

Such systems make it possible to install spot welders of commercial size having a low power demand. The condenser discharge method of spot welding has 3 variables: electrode pressure, voltage and capacity. The increase of time of discharge with increase of gage thickness is practically automatic with condenser discharge, for as the capacity and voltage are increased for gage thickness, the length of discharge is consequently longer.

Aluminum alloys have a sharp transformation with practically no plastic range, and must be liquefied to coalesce. They have relatively high solidification-shrinkage, which causes porosity and marginal cracks to appear in the welds unless the shrinkage is compensated. High pressure welds exhibit a corona around the fused zone where miscibility is effected without melting, thus providing a pocket to prevent loss of liquefied metal.

Marginal cracks and porosity are a function of tip contour and electrode pressure. The higher the pressure, and the flatter the tip, the less is the tendency toward marginal cracking. The recompression cycle to reduce porosity does not accomplish its purpose, and is not necessary on a.c. equipment with proper control.

Surface preparation of aluminum alloys that has been approved by the Army and Navy comprises (1) precleaning with Oakite or Kellite aviation cleaner, or equivalent, to remove vegetable dye, paint, dirt, oil; (2) rinsing in warm water to remove alkaline cleaner; (3) etching the entire assembly in 2-4% hydrofluoric acid by volume for 30-60 sec.; (4) rinsing in water to stop etching; (5) wiping with sponge, etc., for mechanical removal of film left by the etch; and (6) drying with air blast. Additions of 1-2% nitric acid are sometimes made to inhibit the action of hydrofluoric acid.

In dressing the electrodes, it was found that a tip highly polished with jewelers rouge gave greater pickup than when dressed with 7/0 sandpaper, for which no reason could be assigned.

The condenser discharge form of stored energy welding, mentioned above, has had a marked influence on the application of resistance welding to aircraft design and fabrication. This influence is reviewed and analyzed by J. W. DAWSON & B. L. WISE ("Condenser Discharge Welding of Aluminum Alloys," *Am. Welding Soc.*, Paper, Oct. 1941 meeting).

Greater accuracy in this new electrical supply equipment, delivering a single direct current pulse, led naturally to mechanical refinements of the welding machine to match this new electrical supply. Greater electrode pressures were adopted, requiring greater mechanical rigidity. At the same time, considerable advancement was made in the accuracy of static and dynamic pressure delivery. Still further, practically all modern energy storage welding machines employ dual or multiple pressure cycles.

Early spot welding equipment was made universal in form to handle various gages and shapes. Present trends are to more specialized machines and to higher production rate machines, such as the roll-spot and quite possibly jig and fixture machines with appropriate energy storage supply equipments.

The subject of weld quality and weld inspection is at present a most controversial issue in aluminum alloy spot welding. The authors question whether the quality of present aircraft welding is not overly suspected because of occasional cracks in the weld structure. "Perhaps metallurgical perfection is being over-

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emphasized in the absence of sufficiently thorough practical investigations to determine structural adequacy," they declare.

Gas Welding

Gas welding of aluminum is also the subject of continuing study and progress. For example, E. G. WEST ("The Gas Welding of Commercial and Super-Purity Aluminum," *Trans. Inst. Welding, London,* Vol. 4, Apr. 1941, pp. 31-49) presents a report of research on the effect of several factors, including purity, on the gas welding of pure aluminum. Observations were taken during welding and the resulting welds were tested radiographically, micrographically and mechanically.

It was found to be considerably more difficult to weld the higher purity aluminum due to the more copious oxide film, which was more difficult to remove. There was also a tendency for the welding rod to stick to the weld metal, which is ascribable to the complete absence of a freezing range in the super-purity metal. It was also difficult to prevent metal from running through due to the absence of the freezing range, and the masking of the melting point by the oxide film.

The most striking difference between the super and commercially pure aluminum was that the former showed considerably more undercutting at the edges of the weld. The grain size of the recrystallized, heat-affected base metal was smaller for the aluminum of lower purity, indicating that the small amounts of iron and silicon impurity in the commercial purity aluminum exercised a powerful inhibiting effect on grain growth.

Cracking was not found in any of the welds made without constraint; in the constrained welds, the greatest amount of cracking occurred in the commercial purity aluminum welded with rods of the same composition. Cracks were intercrystalline, and were usually situated vertically, either at the junction near the lower side, or near the center of the weld.

Welds made with 4% Si rod showed less tendency toward cracking, but shrinkage cavities were more prominent than when unalloyed aluminum was used. The iron-silicon constituents in commercial purity aluminum segregated at the grain boundaries in the weld, and in the base metal immediately adjacent. This intergranular material of lower melting point than the matrix is considered as the cause of cracking in constrained welds.

In a few cases, cracks were observed in the base metal where it had been heated above the melting point of the iron-silicon phase. Hardness surveys indicate that there are sudden changes in hardness between the weld metal and the annealed zone, and between the annealed zone and unaffected base metal in the case of the hard base metal. Cold working by hammering increased the hardness of the weld metal, but not of the annealed zone; hammering has thus only a relatively slight effect on tensile properties.

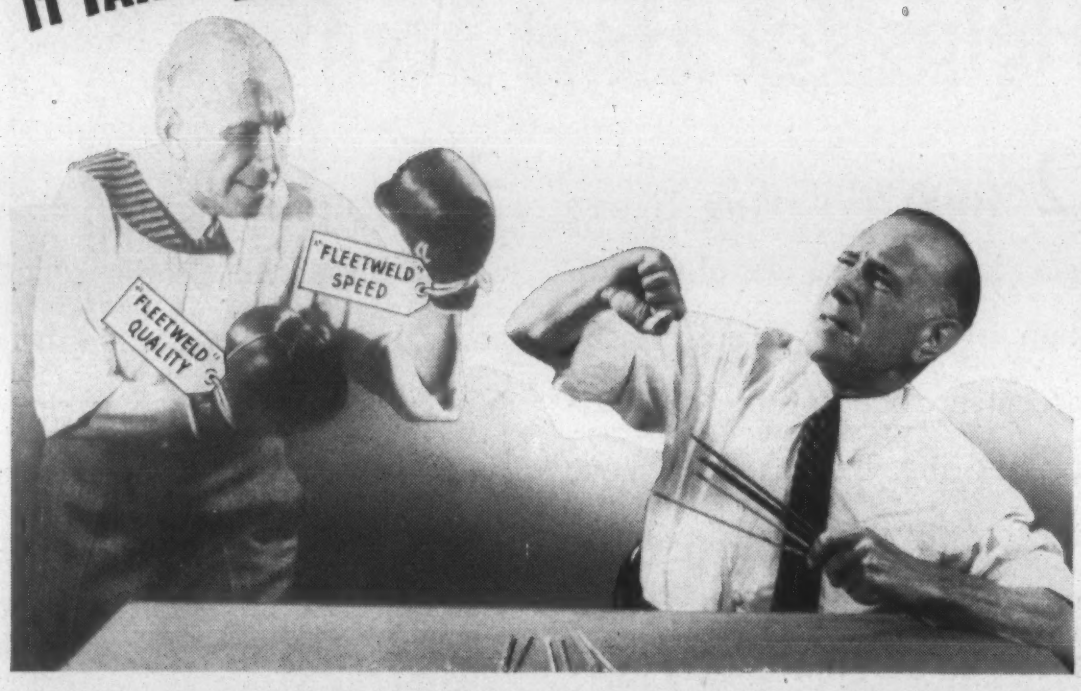
It is concluded that the overall strength of a sound joint is that of the annealed base metal irrespective of the type of filler rod used, or treatment after welding. The corrosion of welds in nitric acid is much more severe in commercial purity aluminum, due to preferential attack at the grain boundaries in the weld metal, and in the junction where the iron-silicon constituent is concentrated.

WEST ("The Fluxing Action in the Gas Welding of Aluminum," *Ibid.*, pp. 50-58) in another article reports on the properties of 15 proprietary fluxes and 40 other mixtures recommended in patents and various other papers for welding aluminum. The investigation included the determination of melting point and hygroscopicity, the solubility of alumina in molten fluxes, and some preliminary work on spreading power and the effect of flux on the apparent surface tension of aluminum.

The most striking result of the research is that, contrary to accepted belief, fluxes for the gas welding of aluminum do not depend for their efficacy on the dissolution of alumina (Al_2O_3). The function of the flux is apparently to attack the base metal, so removing the oxide mechanically, and then to take up the particles of detached film as a suspension. The efficiency of a flux thus appears to depend on the ease with which the halide ions penetrate the oxide coating.

The tests of spreading powder were made to measure the area covered at a standard temperature by a standard weight of flux melted in air on a piece of aluminum. To provide a standardized surface, super purity aluminum sheet was polished mechanically, then anodized by the Bengough-Stuart process to give a heavy uniform film of oxide. The air dried aluminum sheet was loaded in the center with 0.1 gm. of powdered flux to cover a circle approximately ¼ in. diam., then placed in a furnace at required temperature for 16 min. Surface tension measurements by means of the sessile drop method were made on small cylinders of aluminum heated in the

IT TAKES TWO FISTS TO KEEP HEALTHY



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presence of flux, allowed to solidify and measured.

The results so far obtained by this method are of little value, and it appears that other tests yield more useful information as to the relative efficiency of fluxes. The criteria of the efficacy of a flux would be a measure of the degree of ionization at working temperature, rate of penetration of an oxide film, and degree of attack on the base metal. At the same time, the melting point must be low, the spreading power high, and the products of the flux reaction preferably non-hygroscopic. The alkaline halide mixtures of low melting point at present in use appear to be the most effective fluxes. X (2b)

Electroplates on Aluminum

"Last Minute Developments in Plated Aluminum." Raymond F. Yates (Krome-Alume Co.) *Mo. Rev. Am. Electroplaters' Soc.*, Vol. 2, Aug. 1941 pp. 625-28. Review.

The deposition of cadmium or zinc over aluminum should have some useful applications, as these coatings afford good corrosion resistance and make soldering easier.

With the original Krome-Alume process (this consists in first producing an anodic film which is subsequently modified before plating) an adherent coating of nickel could be deposited over aluminum, but the process was not satisfactory for obtaining adherent deposits from cyanide or alkaline baths.

The anodic film on aluminum was originally treated in a sodium cyanide solution. By using an acid solution for modifying the anodic film, direct plating was accomplished without difficulty from all cyanide baths, with the exception of a certain high-pH brass bath. However, ordinary brass plating baths can be used.

The brass plating of aluminum is important because it permits rubber to be fastened to aluminum articles. Copper plating of aluminum costs about $0.015 per ft.^{2} and forms a good base for soldering. AB (2b)

Welding Magnesium Castings

Welding of Magnesium Castings, II ("Das Schweissen von Magnesiumguss, II") Klaus Grassmann & Johannis Brandis. *Z. Metallkunde*, Vol. 33, Apr. 1941, pp. 160-167. Original research. For Part I, see Metals and Alloys, Vol. 13, June 1941, p. 788.

The detrimental effect of inclusions from fluxes applied in welding was discussed in the first part. Part II is devoted to another serious defect particularly encountered in cast material, namely, porosity. The latter may be due to (a) imperfections from the casting process, and (b) excessive preheating of the welding job and subsequent melting out of residual quantities of a eutectic. As the regions adjacent to the weld are necessarily exposed to high temperatures, porosity also shows up around the weld.

The occurrence of the defect is discussed with reference to only 2 of the 3 standard welding methods for magnesium, *i.e.* gas and arc welding. The preheating ranges for gas welding and arc welding are 480°-660° F. and 540°-575° F., respectively. On castings of not too complicated a design, 75% good welds were obtained at 400° F. and 50% cracked at 200° F.

It was found necessary to preheat the casting uniformly and to continue heating (rising hot-air current, sand-bath) during welding. Cooling should be slow and free from drafts. In comparison with aluminum, magnesium requires only ⅓ of the heat for melting the welding rod, ¾ of the heat for raising the temperature of the liquefied weld, and more time for solidification as the thermal conductivity is only ⅔ that of aluminum.

For arc welding, one electrode should be carbon. Illustrations are shown of a casting of 0.20 in. thickness welded with a ½-in. diam. carbon electrode at currents varying from 25 amps. to 280 amps. The optimum range is 50-60 amps. When using a 0.20 in. carbon electrode, best results were obtained at 90-150 amps.

The amperage was less critical with jobs of 10-30 mm. wall thickness; 70-95 amps. is sufficient in this case, using a ½-in. carbon electrode. It is impossible to weld large wall thicknesses with thin carbon electrodes. Using carbon electrodes larger than ½-⅝ in. diam. offers no advantage even with heavy cross sections.

The best current densities are 0.5-1.0 amps./mm.^{2} and 4.5-7.1 amps./mm.,^{2} respectively, for ½-in. and 0.20-in. carbon electrodes. Diagrams show the necessary welding time for different sizes of magnesium and aluminum welding rods.

In gas welding, small tips are used, much smaller than for aluminum. Either a neutral flame, or an excess of gas are advised, in addition to the use of the shortest possible welding times. With the fluoride-base fluxes, recommended in Part I, porosity around the weld may be suppressed. The liberated fluorine vapor seems to prevent oxidation.

As to cast alloys, difficulties in welding are attributable to porous and oxidized structure, coarse grain, and residual stresses from casting. Microstructures of weld, transitional region and parent metal are shown for heat-treated and as-cast magnesium alloys. For aluminum-bearing magnesium alloys (up to 10% Al), solution-annealing of welded parts can be effectively carried out.

Statistical evaluations show that samples including the weld are 5-15% lower in tensile strength than samples taken from the adjacent areas of the unwelded, finely porous parent metal. Nevertheless, the fracture occurs in most cases outside of the weld. Fatigue bending tests yielded an average of 8-10% lower values for the weld than for the unwelded material.

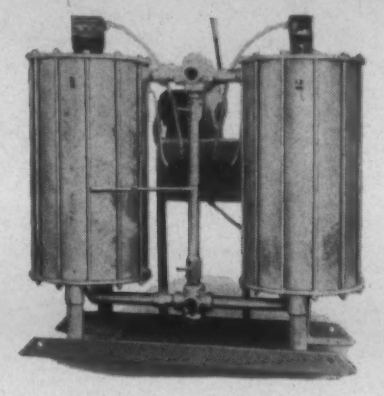
EF (2b)

Atmospheres for Copper Alloys

"Prevention of Oxidation Type of Reaction in the Heat Treatment of Copper and Its Alloys." E. G. deCoriolis & Wm. Lehrer (Surface Combustion Corp.) *Am. Soc. Metals*, Preprint 33, Oct. 1941 meeting, 12 pp. Review.

As in the ferrous field, the non-ferrous industry has in recent years shown a steadily increasing trend toward the mechanization of its forming and processing operations. Fully mechanized furnaces are used whenever possible. Close automatic control of the temperature and of the entire furnace operation is standard practice, and modern controlled atmosphere furnaces are rapidly replacing the old style furnaces. Also, it is now considered good practice to bright anneal most non-ferrous metals in the atmosphere of the gases as they are formed in the combustion of a reducing air-gas mixture.

Most atmospheres used in commercial furnaces are mixtures of various gases,



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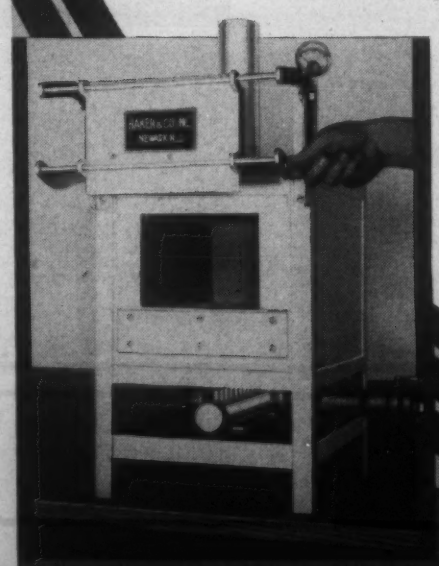

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such as carbon dioxide, carbon monoxide, hydrogen, nitrogen, water vapor and traces of methane. Such an atmosphere is inert to pure copper, and, in fact, is capable of reducing copper oxide back to metallic copper, so that an article of copper which may have been tarnished or oxidized will, upon heat treatment in such an atmosphere, be restored to full brightness.

This reducing action may result in harmful effects if the gas mixture is so proportioned as to contain in excess of 1% H. Many articles of copper are made directly from the electrolytic and non-deoxidized metal which contains a eutectoid of cuprous oxide. The reduction of this oxide during heat treatment in an atmosphere containing an excess of hydrogen will result in embrittlement of the product. If the copper has been previously deoxidized at the refinery, the limit of hydrogen in the heat treating atmosphere may be raised without harmful effects.

Free oxygen in the atmosphere, on the other hand, even though present in such small quantities that it cannot be detected by the usual gas analyzing apparatus, will oxidize copper. It is important, therefore, when using an atmosphere resulting from the combustion of fuel gas to insure its complete combustion.

One of the most serious problems occasionally encountered in the bright annealing of copper is sulphur contamination of the atmosphere. The sulphur is most active and damaging to the surface of the work when it is present in the form of hydrogen sulphide, whereas sulphur dioxide is practically inert. The most common source is in the raw gas used in the production of the atmosphere.

To reduce the hydrogen sulphide from the fuel gas source, the raw gas is purified as much as possible by passing it over iron oxide for the removal of hydrogen sulphide. Then the air-gas ratio of the mixture is set close to perfect combustion, leaving only about 1.5% of combustibles in the products of combustion so as to oxidize most of the sulphur to the inert sulphur dioxide. In the case of a special gas preparation unit, the combusted gases are cooled in direct contact with cooling water, which absorbs a large percentage of the sulphur dioxide, and the gas is then finally purified in another iron oxide tower.

Practical experience has shown that in an open-fired furnace bright copper, free from sulphur staining, can be produced with as high as 6 grains of sulphur per 100 cubic ft. of raw manufactured gas, provided the carbon monoxide content of the products of combustion is held below 2% by volume. In a convection-type heating furnace, on the other hand, the sulphur content of the raw gas must be extremely low because the gases are circulated at a high velocity over the work, thus bringing most of the hydrogen sulphide molecules in contact with the work.

Among the alloys, those of copper with silver or with nickel behave with respect to atmospheres in a manner similar to copper itself. The alloys of copper with zinc (*e.g.* yellow brass) present far greater difficulties in preserving their bright surface during heat treatment. Zinc when heated oxidizes readily in air, but it also is oxidized by hot carbon dioxide gas and water vapor.

An atmosphere suitable for the prevention of surface oxidation of brass at annealing temperatures must, therefore, exclude these gases. This necessitates the use of either an inert gas, such as nitrogen, or one which is actively reducing, such as hydrogen or a hydrogen generating gas. In the latter class may be cited such atmospheres as are produced by methanol or decomposed hydro-carbon gases.

From a commercial aspect, it is actually unnecessary to avoid oxidation, because the oxides usually formed are easily pickled in dilute sulphuric acid. On the other hand, *excessive* oxidation is to be avoided and atmospheres must be controlled to produce an oxide that is easily flash pickled. The surface resulting from such practices is commonly referred to as "clean annealed."

Alloys of copper with tin, lead and aluminum are also oxidizable in atmospheres that oxidize yellow brass. Common practice is to clean anneal and to pickle these alloys with yellow brass. The commercial output of these alloys has not reached the stage where heat treatment in perfectly inert atmospheres is desirable or necessary. (2b)

An

INDEX

to the 1940

"METALLURGICAL ENGINEERING DIGEST"

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METALS and ALLOYS

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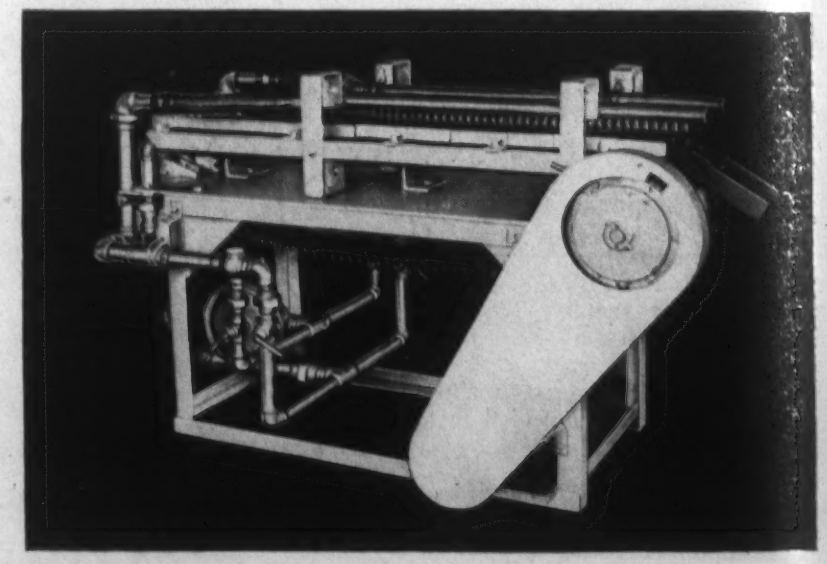

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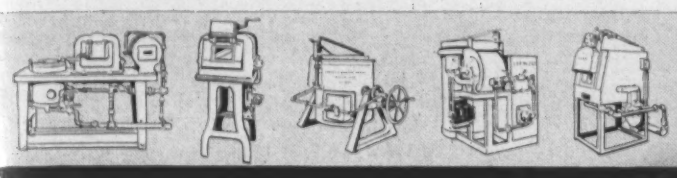

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regularly manufacture 45 non-ferrous and 12 ferrous alloys for use in their various manufacturing processes.

Ajax-Northrup Furnaces are used extensively because of their flexibility and precision control and because laboratory developments can be transferred to large scale factory production with larger Ajax-Northrup Furnaces with predetermined results.

The illustration above shows one of two Ajax-Northrup tilt type high frequency furnaces supplied with power from a 111 KW high frequency generator. Ajax-Northrup lift coil type furnaces are also used for material testing.

Information of special interest to laboratory and metallurgical executives will be sent on request.

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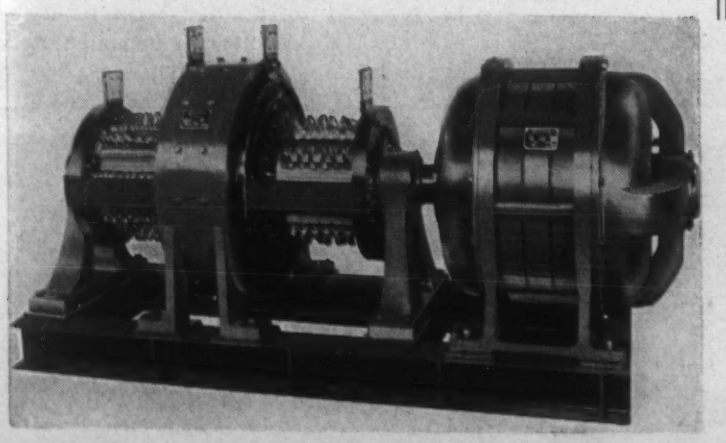

Columbia Motor-Generator Sets are a valuable asset in meeting the precision requirements of the modern plating department and embody every feature essential to dependable, 24-hour operation. They are built in sizes of ½ to 250 KW, 100 to 40,000 amperes, 6 to 60 volts. Prompt shipment can be made on any size.

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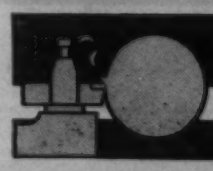

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Materials in 1942 Car Design

A Composite

The past year saw an increasing amount of the engineer's time being diverted to defense needs. And much of the time he had left to spend on the design of civilian supplies was used up in calculating how to overcome the ever-increasing shortages of the materials out of which he was expected to build new and continually better products.

Some Typical Alternates in 1942 Cars

Part	Former Material or Methods	Alternate Material or Methods
Steering Knuckles	3135A	4140
Trim	18-8 Stainless	18 Cr Stainless
Exhaust Valves	Cr Ni (1½-12% Ni)	7-18% Cr, 2-3½% Si
Connecting Rod	1045	X1345
Pistons	Secondary Aluminum	Cast Iron, Cast Steel
Cylinder Heads	Aluminum	Cast Iron
Brake Wheel Piston	Aluminum	Powdered Metal
Grilles	Die-cast Zinc	Stamped Steel
Instrument Panel Grille	Die-cast Zinc	Plastic
Reflector (Lamp)	Silver-plated Brass	Glass
Shift Control Arm	Die-cast Zinc	Forging

The automotive engineers in particular were "on the spot." Besides the heavy responsibility placed on them for the production of armored equipment, they were faced with the task of continuing their policy of introducing new refinement and designs to the modern automobile. This they did, and did well.

The designs and innovations of the 1942 automobiles were analyzed and described in two articles recently published ("Automotive Design in the 1942 Cars," *Product Engineering*, Vol. 13, Oct. 1941, pp. 516-525, and "1942 Car Design Trends," THOMAS A. BISSELL, *S. A. E. Journal*, Vol. 49, Nov. 1941, pp. 465-480).

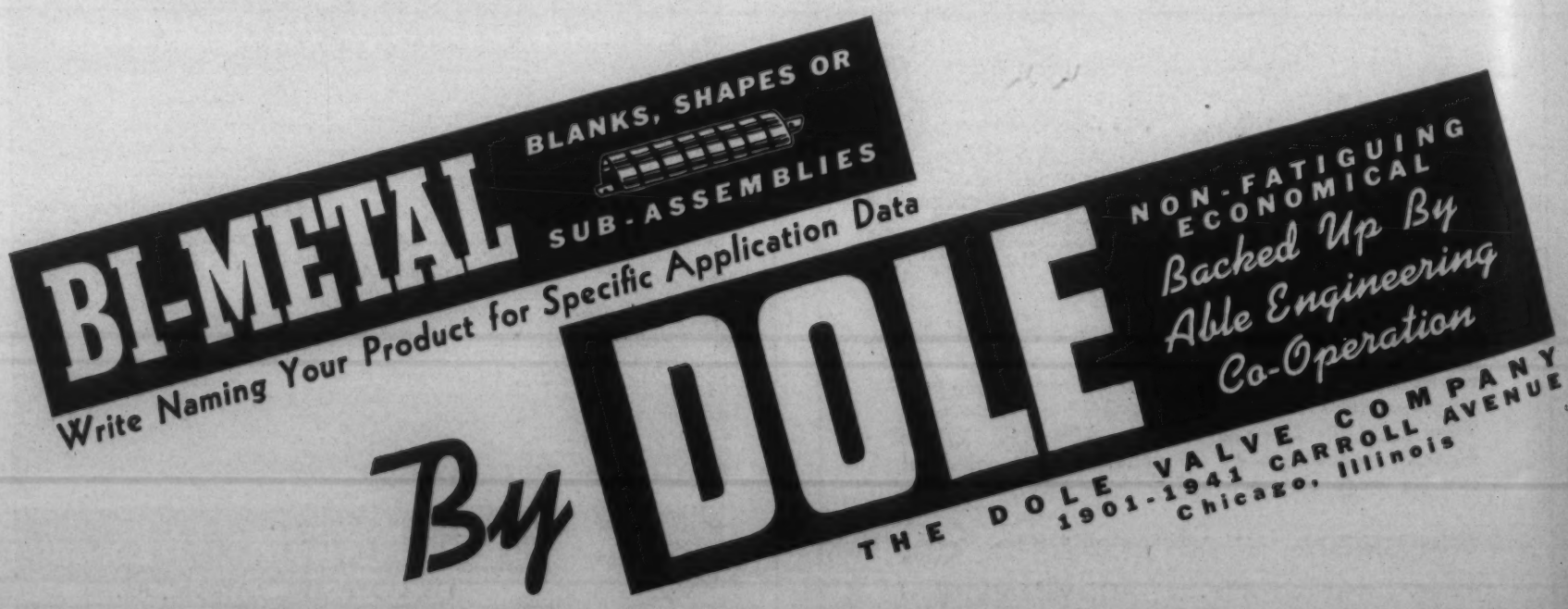
Material shortages, of course, were the primary factor of consideration in any redesigning or refinements. In fact, some redesigning was necessary as a direct result of material shortages. The 3 materials that caused the most trouble on this score were aluminum, zinc and nickel steel.

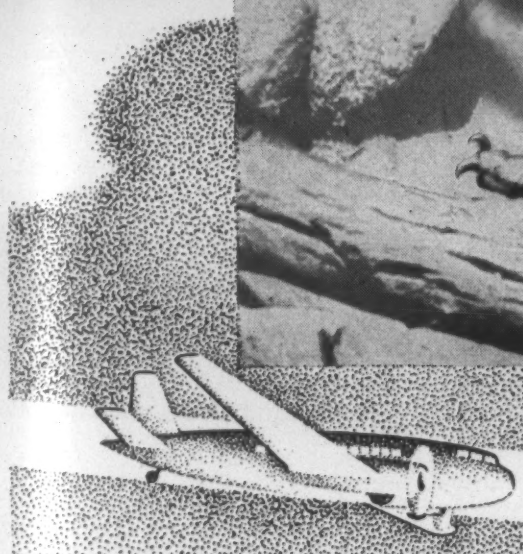
Many of the companies had been using aluminum pistons, and the change to a cast-type piston brought problems of lower thermal conductivity, reduction to half the thermal expansion and increased reciprocating weight. It was fortunate that most manufacturers last year had adopted thin-babbitt bearings, backed by steel or by powder-iron matrix, because these bearings have sufficient fatigue strength to take the increased load caused by cast pistons.

Oldsmobile has developed a piston design using ArMa steel, a pearlitic malleable iron. Pontiac is continuing the use of cast iron pistons, tin plated. Other makers are Parco-Lubrizing their cast iron pistons. This process produces an oxide coating that tends to hold oil and insures smooth operation.

Zinc die castings have been cut down considerably in number. Many parts are being made of stamped steel or of plastic over a steel core. Some ornaments are die cast of antimony lead. Zinc die cast grilles have been entirely replaced by steel stampings. Packard's transmission cover, formerly of zinc, is now cast iron.

Contrary to general opinion, priorities have not affected the shiny trim on the new cars. Chromium plate and stainless trim have been used extensively since many of the companies had considerable fabricated stock on hand. The bright trim, however, is expected gradually to disappear and will be replaced by painted strip or extruded plastics. Oldsmobile is experimenting with aluminum paint for such parts.





COMING IN ON THE BEAM

Powder Metallurgy makes possible unique properties in certain parts which actuate the automatic landing of airplanes by radio beam control. A single part may combine the properties of high grade iron at radio frequencies, and those of a good ceramic insulator at power frequencies.

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METAL POWDERS SINCE 1916

For obvious reasons, only mechanical changes necessitated by material shortages were adopted. As was previously mentioned, most manufacturers changed over to cast iron or cast steel pistons. The elimination of aluminum alloy cylinder heads and of the nickel content in valves required a number of design changes.

The adoption of cast iron and cast steel pistons has necessitated heavier crankshafts with larger bearings on some engines. Buick introduced a "rough" finish on its crankpins, claiming increased bearing life and capacity.

The table is a condensed version of the one appearing in *Product Engineering*, and gives a good idea of some of the typical alternates in 1942 cars. HRC (3)

What's in a German Aero Engine?

"Mercedes-Benz DB-601A Aircraft Engine—Design Features and Performance Characteristics." Raymond W. Young (Wright Aeronautical Corp.) *S.A.E. Journal*, Vol. 49, Oct. 1941, Trans. pp. 409-431. Descriptive.

A teardown inspection has been made of a typical high-production German engine. The examination included Magnaflux inspection, analysis of materials, and tests of quality of finish.

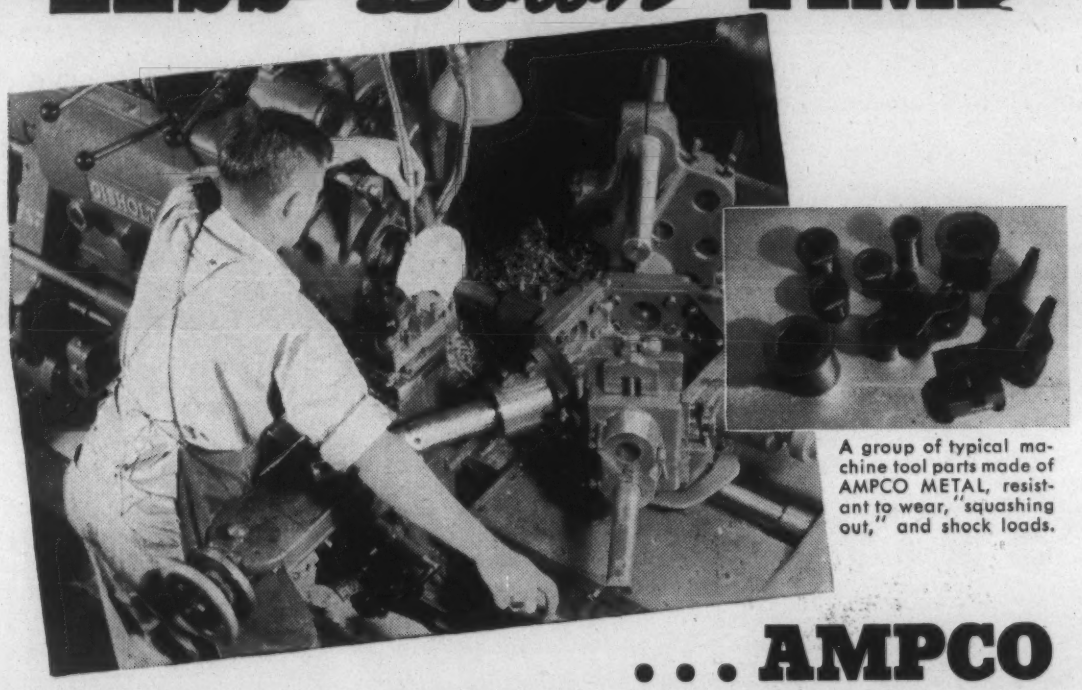
Magnaflux inspection of a representative number of highly stressed steel parts indicated that the material used in this engine was comparable in standards of acceptance to American aircraft engine quality. Comparison of the surface finish of various parts with that of equivalent "Cyclone" engine parts showed a close degree of similarity in the standards for quality of finish.

Apparently no useless effort in man-hours or finish was expended where there is not a direct return in increased reliability and performance. The handiwork in polishing of stressed parts is of the highest order.

Chemical analysis, hardness, and structure of metals used in major parts indicated that the materials used are on a par with those used for similar purposes in American engines. There is no apparent sacrifice in the quality of materials used in German aircraft engines up to at least late 1939.

There did appear to be a tendency to eliminate nickel, but there is no appreciable evidence that at that time there was any shortage of tin, chromium, tungsten and other strategic alloying elements for the German aircraft industry. A surprising observation was the almost total absence of magnesium alloys in this German engine. MS (3)

LESS "Down" TIME



A group of typical machine tool parts made of AMPCO METAL, resistant to wear, "squashing out," and shock loads.

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PROTECTS VITAL PARTS AGAINST FAILURE

"Down" time, due to the necessity of replacing worn or weakened parts in machine tools, results in loss of service and disrupts production lines. Bronzes in vital frictional parts must help maintain continuous, uninterrupted operation . . . Over sixty machine tool manufacturers have standardized on parts made of AMPCO METAL, an alloy of the aluminum bronze class, because of its stubborn resistance to wear, impact, and failure. They know by actual experience that longer service life, freedom from breakdown and delay, less maintenance and fewer replacements follow the use of AMPCO METAL. Typical parts are bushings, bearings, gears, worm wheels, shifter forks, lead screw nuts, liners, gibs, sleeves and shoes.

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Corrosion of Electrical Equipment

"Corrosion in Electrical Machinery." W. Subak. *Elec. Review*, Vol. 129, Sept. 5, 1941, pp. 192-194. Practical.

When a machine is continuously subject to a contaminated atmosphere, its inner surfaces are difficult to protect. The most efficient machines for the chemical industry are those with cast-iron casing and those with welded casings of rolled steel.

Under very severe conditions, the only solution is to use totally inclosed machines. Pipe or dust ventilation is necessary, because even such machines are seldom completely air-tight. Drainage holes will prevent accumulation of water due to condensation. The formation of moisture on large machines can be avoided by heating them with elements fitted in the lower parts.

In bearings with sliding friction, the corrosion of the shaft ends and of the brasses may be caused by electric currents in the bearings. Because the magnetic path is not perfectly symmetrical, variations of flux arise, causing potential differences in the system shaft-bearing-pedestal-bearing-shaft. Shaft end and brasses act as electrodes inside the bearing, while oil acts as an electrolyte. Isolating one of the bearings from the pedestal will interrupt this circuit, thus eliminating danger to the bearing.

The effect of currents caused by an alternating magnetic flux in the shaft created by certain connections in 3-phase machines or the constant magnetization of the shaft of some d-c. compound-wound machines is similar to that in bearings. These currents cannot be interrupted, but the disturbing flux can be reduced by putting non-magnetic elements in the system shaft-bearing-pedestal.

Connecting the shaft and casting with copper-gauze brush has been found useful. Another method of damping parasitic alternating flux in 3-phase machines is to use short-circuit rings on the front of stator windings and around the bearing pedestal.

Corrosion fatigue is of little importance in electrical machines. Parts subject to alternating forces are the shaft and the screws of some armatures. While screws are less exposed to corrosion, it is advisable to protect them by cadmium plating. Damage to armature shafts does not occur, while the protective paint of the free shaft prevents corrosion by damp air.

Parts that carry the current or are the medium of the magnetic circuit require the most effective protection against corrosion. Synthetic resin varnishes are available that offer complete resistance to water, heat,

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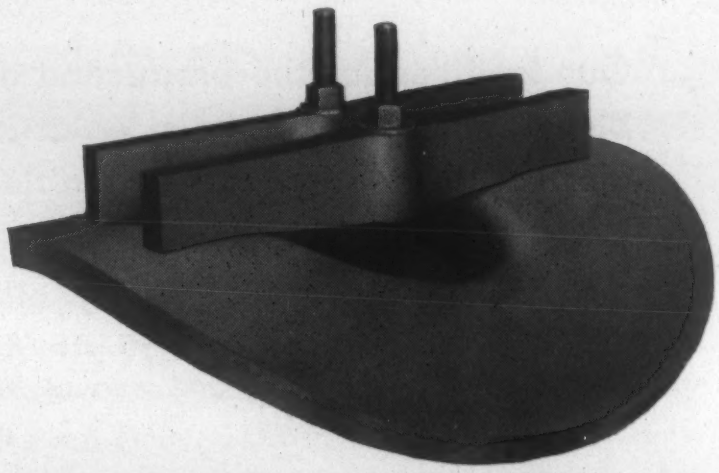
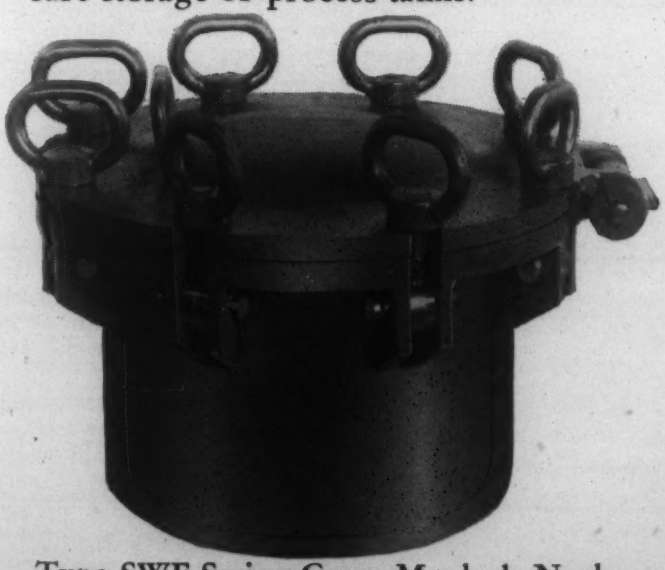


Heavy Manhole saddles with machined cover for elevator systems on Aircraft Carriers.



Type SWE Swing Cover Manhole Necks for Process Apparatus in manufacture of high explosives.

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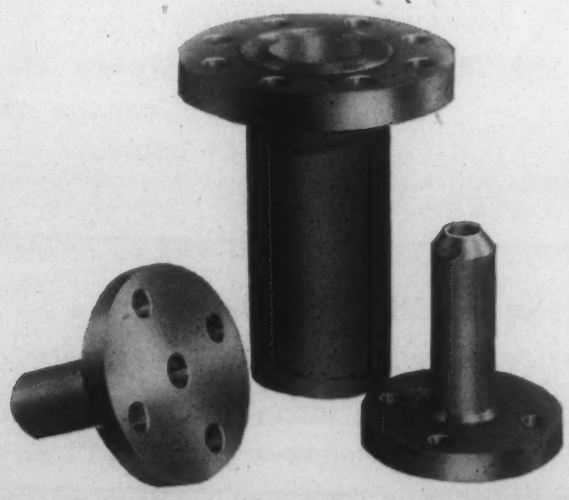

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acids, alkalies, etc. The most effective varnishes are made of phenol and its derivatives and are oven-dried at 350°-400° F.

Good insulating varnish for cores must adhere well to the sheet, withstand chemical influence, not splinter when the sheet is punched, and coat evenly in dipping. Corrosion of windings may arise chiefly from destruction of insulation by acids, water, vibration, etc., but present-day protective varnish is of a very high standard.

Condensation may be dangerous to windings equipped only with normal insulation. In high-voltage machines, difference in voltage between the individual coils may give rise to glow-discharge which decomposes the damp air. Nitric acid formed affects the normal insulation. Glow-discharge may be countered by painting the windings inside the slots with a conducting varnish.

Disturbance may be caused by verdigris on impregnated windings. It may be due also to fungus on the covering of the wire after storage in damp air; contact of insulation with perspiration from armature winding or salty grease; leaving impregnated coils too long in damp air before oven drying; ozone, and, if air is damp, nitrous acid produced by discharges in slots of high-voltage machines during working; and absorption of oxygen by the oil in the varnish, copper conductors acting as a catalyst.

Nitric and nitrous acids may be prevented by impregnating the windings with organic bases such as diphenylamine or its solutions. Suitable design, and particularly mechanical design of the windings, will counteract condensation.

Brush strands, which are bare, are particularly liable to corrosion in atmospheres containing hydrogen sulphide. Flexible copper straps instead of strands temporarily provide greater resistance to corrosion, but sulphur makes them hard and brittle after a certain period. The best solution is to use strands provided with efficient protection such as a tin coating.

Of the light alloys employed in electrical machines, the most widely used is the aluminum-silicon group, which has great corrosion resistance. In cases of combinations of magnesium alloys with heavy metals, possibility of electrolytic corrosion must be considered. MS (3)

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3a. Ferrous

Selection of Hardened Surfaces

SURFACE HARDENING OF HIGHLY STRESSED MACHINE PARTS ("Oberflächenharten hochbeanspruchter Maschinenteile) H. WIEGAND. *Maschinenbau-Betrieb,* Vol. 20, Feb. 1941, pp. 69-71. Practical review.

Besides increasing the wear resistance, surface hardening of steel or iron also improves its endurance under dynamic stress conditions. The specific method of hardening is chosen according to the material, stress and distortion condition.

For carburizing, alloy or carbon steels with less than 0.22% C are recommended. For the nitriding process alloy steels are used with 0.22 to 0.4% C. Carbon and alloy steel with at least 0.3% C are used for flame and induction hardening.

In carburized steel the greatest hardness exists at the surface, and it stays nearly constant until the carbon content drops off toward the interior. The maximum hardness obtained by nitriding is greater and it appears slightly below the very surface. The total penetration in nitriding is not so deep as in carburizing. The greatest depth of hardness can be obtained by flame or induction hardening, although the maximum hardness is usually less.

If the part is in the heat treated condition to start, too great a depth of case should not be aimed at because there is danger of the formation of an annealed zone between the case and core. For production purposes the grinding allowance for case hardened parts should be as small as possible. Nitrided parts should always be either ground or lapped.

Case hardened parts should not be used in places where impact occurs. Holes should be drilled before the part is case hardened. Interruption of the hardened case and transition points in selective hardening are danger points under fatigue stresses.

Annealing of carburized parts reduces internal strain. Nitrided, flame and induction hardened parts are usually not annealed. Operating temperatures should be below 300° F. for carburized parts; for higher temperatures nitrided parts are used to advantage.

The quality of the surface before case hardening does not have an appreciable influence on the endurance. After the treatment, however, the steels are very sensitive to surface scratches, especially the nitrided materials. Parts so treated should be carefully protected during transportation and assembly.

If straightening is necessary this should be done in sections that are not case hardened. Sometimes special nonhardened zones have to be left in order to allow for straightening. RPS (3a)

For all-around Conservation

LET'S LIGHTEN THE REPLACEMENT LOAD

Replacement of the planes, tanks, trucks, guns, ships, and machinery now in production will soon impose a tremendous added burden on the Nation's productive facilities. High among the many excellent materials able to lighten the replacement load by insuring long service to machinery parts for defense and civilian use, stands Nitralloy.

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Thus Nitralloy, by conserving the fruits of our labors, stretches our resources of steel, fuel, power, transportation, plant facilities and personnel.

Obviously the same properties that made Nitralloy a veritable life preserver for defense material, find wide application in the normal activities of industry.

For complete technical details and list of applications, write for the Nitralloy Data Book—and feel free to consult us regarding the best Nitralloy formula and treatment for any given purpose.

NITRIDING

is the process of case hardening certain alloy steels by means of a nitrogenous medium, such as ammonia gas. The alloy steels that are most suitable for Nitriding are known as

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Wear-Resistant Cast Irons

"Reports on Special-Duty Cast Irons. III—Martensitic Cast Irons." J. G. Pearce. *Foundry Trade J.*, Vol. 65, Sept. 4, 1941, pp. 158, 154. Review.

Martensitic cast irons have been developed in recent years to take advantage of the resistance to wear, erosion, and abrasion associated with the martensitic structure, and they are applied in engineering accordingly. Martensitic cast irons may be produced by heat treatment of an ordinary engineering (pearlitic iron,) or they may be specially produced and so treated that either of 2 varieties can be obtained.

In one such variety the eutectic filling surrounding the primary grains is allowed to solidify white (cementitic), and in the other it is allowed to solidify gray (graphitic). The "gray" variety can be made martensitic in the condition as cast, or, alternatively, a martensitic structure can be produced in it by suitable heat-treatment.

While a great deal of experimental work has been done on the production of the less hard, or gray, variety of martensitic iron, the greater industrial need has been for the harder variety, and it is for this type that the bulk of the information recorded is available. This type has various trade names, perhaps the best known of which is "Ni-hard."

The chief feature of the Ni-hard composition is about 4.5% Ni and 1.5% Cr; the other elements resemble those in chill-cast irons, silicon being relatively low. For the highest hardness, the carbon content is raised to a maximum, and for the highest strength it is lowered to a minimum; in general carbon and silicon contents are higher in small castings.

Ni-hard irons are not usually employed for their resistance to corrosion or heat, but for their resistance to wear, erosion, and abrasion. They offer no increase in ductility or elongation over the ordinary engineering gray irons. AIK (3a)

Brake Drums and Linings

"Effect of Roughness of Cast-Iron Brake Drums in Wear Tests of Brake Linings." Rolla H. Taylor & William L. Holt. *J. Research Natl. Bur. Standards*, Vol. 27, Oct. 1941, pp. 395-404. Research.

Five representative types of commercial brake linings were tested against centrifused cast-iron brake drums having widely different values of roughness.

It was found that (1) the rate of wear of brake lining is an increasing function of the initial roughness of the drum, (2) the actual wear characteristics of a given lining are a function of the character of the surface of the drum and of the type and quality of the lining, (3) the roughness of the drums, in general, has a greater effect on the wear of woven linings than on the wear of molded linings, and (4) the rate of wear of brake linings tested against relatively smooth drums becomes practically constant after the first few hundred stops.

For relative wear tests a drum of specified type and finish, having a roughness of not more than 15 microinches root mean square is recommended. The effect of the roughness of brake drums in service is probably similar to that obtained on the testing machine but less in magnitude. The coefficient of friction appears to be slightly lower the rougher the drum, but for all practical purposes the effect of roughness on the coefficient of friction may be neglected. WAT (3a)

3b. Non-Ferrous

Glass for Aluminum in Recorders

"Research Beats the Priorities." C. J. LeBel. *Electronics*, Vol. 14, Oct. 1941, pp. 27-30, 78-83. Descriptive Survey.

The search for a material to replace aluminum, now unavailable, for recording discs has resulted in the development of a superior professional material for the purpose. Glass is the new substitute.

The professional record user wants a base material with extreme flatness and a perfectly smooth surface. Early in 1939 the search for a new base material for professional instantaneous recordings was begun. There followed tests with cardboard, hard fibre, other pressed boards, and synthetic resin plastics. None of these proved satisfactory, and the tests were shifted to the more likely usable metals for a base material.

Zinc, zinc alloys, copper, copper alloys, and steel were tried. Zinc and steel were found to be the best of the metals. However, about this time zinc became scarce and had to be eliminated. Only steel was left, and this was not entirely satisfactory to the most critical users.

From previous experiments, it was known that glass, when made by the right process, has a very flat and flawless surface, so glass was the material adopted. The problems encountered were numerous. First was the question of thickness. Durability and correct thickness to fit existing machines had to be considered. It was found that a base

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thicker than about 0.065 in. produced a record of excessive thickness.

Other problems, such as cutting and drilling, and the matter of surface cleanliness to insure a good adhesion of the lacquer all had to be solved.

Finally, the shortage of brass and kindred metal required the adoption of a substitute for the center circle of the recording disc. It was found possible to devise a special non-metallic bushing with a punched center hole.

Recording engineers have found that the glass base discs sound better and clearer, possibly due to the better internal damping of vitreous material. The problem of packing, shipping and handling the more fragile glass base discs has been solved so that now it appears as though glass has become the permanent substitute. HRC (3b)

Fatigue of Magnesium Alloys

FATIGUE PROPERTIES OF MAGNESIUM ALLOYS ("Dauerfestigkeitseigenschaften der Magnesiumlegierungen") W. BUCHMANN. *Z. Ver. deut. Ing.*, Vol. 85, Jan. 4, 1941, pp. 15-20. Research.

The fatigue behavior of magnesium alloys at about 600 million load oscillations lies between that of the soft steels and of aluminum alloys of the same strength. The bending fatigue strength and notch-sensitivity of commercial magnesium alloys are given in a table.

The magnesium casting alloys have fairly low notch sensitivity values, so low in fact that they are even more sensitive than aluminum alloys. The notch-sensitivity of magnesium casting alloys is the least for those of homogeneous structure. The wrought magnesium alloys show the same sensitivity values as the hardenable aluminum-copper-magnesium alloys.

The numerical values of bending fatigue strength decrease with increasing section in all materials. The ratio of push-pull fatigue strength to bending fatigue strength was found, for rods of 0.30 in. diam., to be about 0.63 in wrought alloys, and 0.48-0.63 in the cast alloys; the aluminum-copper-magnesium and aluminum-magnesium wrought alloys showed the same ratio as the magnesium wrought alloys. [*This ratio seems decidedly low, as if the push-pull tests were not quite axially loaded. True axial loading without bending is very difficult to attain in push-pull fatigue tests. —H. F. M.*]

Torsion and bending fatigue strength were in a ratio of 0.55-0.60 in casting alloys and 0.45-0.60 in wrought alloys. Surface quality has a very decided effect; fine surface cracks in the casting skin, roll skin, pickled or filed surfaces, etc. reduce fatigue strength well below the figures for polished surface. Ha (3b)

Beryllium and its Applications

"BERYLLIUM—ITS PRESENT FIELD AND POSSIBLE FUTURE APPLICATIONS." LOUIS L. STOTT (Beryllium Corp. of America) *Steel*, Vol. 109, Oct. 27, 1941, pp. 62, 64, 92-93. Review.

Beryllium is very light (sp. gr., 1.8) and its calculated modulus of elasticity is about 30% higher than that of steel; its electrical conductivity is about 1/12 that of copper; the melting point of the metal is 2350° F.; and its thermal expansion lies near that of iron. The hardness varies with the purity of the metal, being 120-140 Brinell for 99.8-99.9% pure metal. It is non-magnetic and has a great affinity for oxygen, nitrogen, silicon and carbon.

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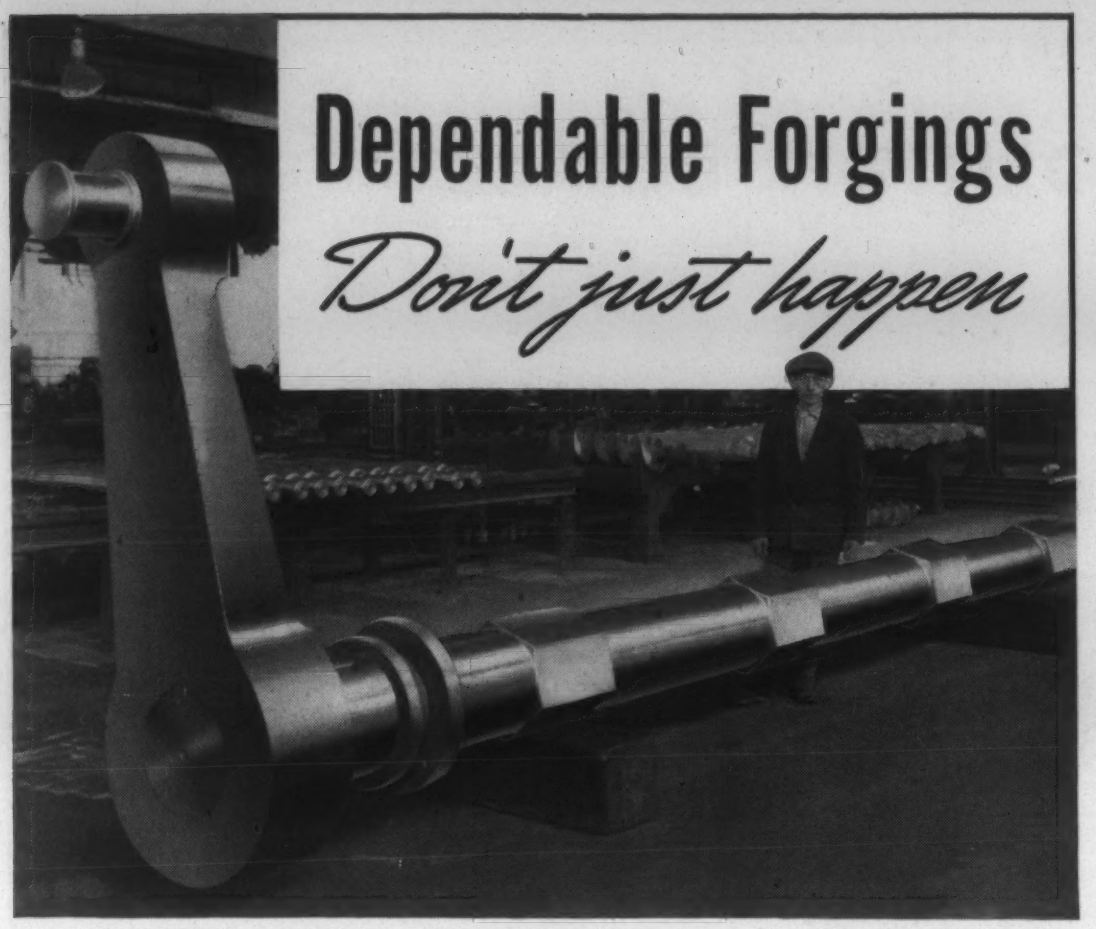

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The commercial applications of the pure metal are limited principally to industrial X-ray tubes. Commercially prepared metal of 99.5% purity appears to lack sufficient malleability for structural purposes.

Alloys of beryllium with aluminum and magnesium still are very much in the laboratory stage. While beryllium-aluminum alloys containing as much as 70% Be have high tensile strengths, they are described as too brittle and too expensive. There may be possible uses of beryllium as a stiffener of aluminum or its alloys when the application warrants the high cost.

Of the 5 different compositions of beryllium-copper commonly sold, about 80% of the alloy consumed at present contains about 2% Be. This small addition enables the copper to be hardened by cold work and heat treatment to more than 6 times its normal annealed strength. Beryllium-copper wire has been drawn to a tensile strength of 220,000 lbs./in.^{2}

Addition of about 0.25% of other elements, principally cobalt, to the 2% Be alloy improves the properties for certain uses. Such alloys have high electrical conductivity, tensile properties and hardness. They can be formed in relatively soft temper, and then be given high spring properties by a simple one-step, low-temperature heat treatment.

Thus, wire for helical springs has been furnished at tensile strengths of 90,000-120,000 lbs./in.^{2} Subsequent age hardening increases the tensile strength to 180,000-220,000 lbs./in.^{2}

Where subsequent heat treatment cannot be given, a wire has been developed containing 1.8-2% Be, 0.2% Co, and the balance copper. It is given a special precipitation hardening treatment instead of the last anneal, and then is cold drawn to final gage. Its tensile strength is 175,000-200,000 lbs./in.^{2} as-received and its endurance limit is very high. A ½-in. bar stock of a copper alloy containing 1.8% Be and 0.13% Co, cold drawn 40%, and heat treated 3 hrs. at 700° F., had 158,000 lbs./in.^{2} tensile strength, 20% elongation in 2 in., 29% reduction in area, 33 Rockwell C hardness.

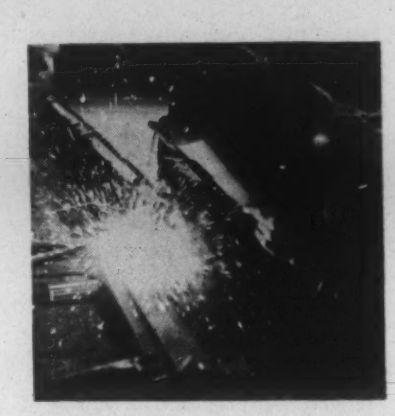
An alloy containing 0.45% Be, 2.6% Co and balance copper has possible uses where heat conductivity is a factor or where resistance to heat checking under frictional contact with materials used for brake blocks or clutch facings is desirable.

Beryllium-nickel is not yet available commercially in the United States, but it has been produced successfully in Europe. Strip containing 1.8-2% Be and balance nickel, heat treated after cold rolling to 50% reduction, had 270,000 lbs./in.^{2} tensile strength, 238,000 lbs./in.^{2} yield point, 27,000,000 lbs./in.^{2} Young's modulus, 8.8% elongation in 2 in., and 480 Brinell hardness. The use of highly stressed thin sections of this material offers possibilities of obtaining weight savings.

The most numerous applications of beryllium-copper alloys have been for various types of springs, clips, electrical contacts, diaphragms, and similar articles. In addition, the good resistance to wear and shock and the compressive strength of beryllium-copper are increasing its applications where these factors are the primary considerations in selecting material—for example, in machines and engines for heavily loaded bushings in contact with a hardened steel shaft where action is eccentric or reciprocating; valve seats and tappet rollers; resistance welding electrodes; cam stops; and switch lever and latch on indexing mechanism of an automatic screw-machine.

MS (3b)

WELDING



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4 Testing and Control METHODS, EQUIPMENT

Physical and Mechanical Property Testing and Inspection. Routine Control and Instrumentation. X-ray and Magnetic Inspection. Spectrographic and Photoelastic Analysis. Corrosion- and Wear-Testing. Examination of Coatings, Surface Measurements. Metallographic Structure and Constitution.

Magnetic Testing

"Magnetic Testing." J. Seifert (Babcock & Wilcox Co.) *Iron Age*, Vol. 148, Oct. 9, 1941, pp. 64-73. Investigation.

The characteristics of 5 magnetic powders are investigated by the dry method. This method consists of dusting a dry powder of high magnetic permeability upon a previously magnetized area. The following qualities were considered: (1) Distinctness, (2) adherence, and (3) depth effect.

The powders studied included: (a) gray Magnaflux; (b) E & E Magnaflux crack detector; (c) magnetite (250 mesh); (d) plastic iron powder (100 mesh); and (e) Smooth-On "iron cement." A 14 x 1½ in. test plate was used with a tapered weld groove starting at the top surface at one end and increasing in depth to thickness of the plate at the other end.

The results showed that powders (a), (b) and (d) give better results as to distinctness and adherence than powders (c) and (e). Further tests were designed to determine the effect of separation of the crack faces and the depth of crack below the surface upon test methods. Powders (a), (b) and (d) show the maximum depth effect, revealing sub-surface cracks of 0.313 in.

The results showed that powders (a), (b) and (d) display the best characteristics. Powders (c) and (e) are particularly deficient in distinctness and also do not show the same adherence and depth effect as the other 3 powders.

For inspection of surface cracks and in general all weld inspection, the best values to use are from 350 to 700 amps. As the defect becomes larger, it is harder to locate if its depth below the surface increases, particularly if it is more than 2½ in. below the surface. VSP (4)

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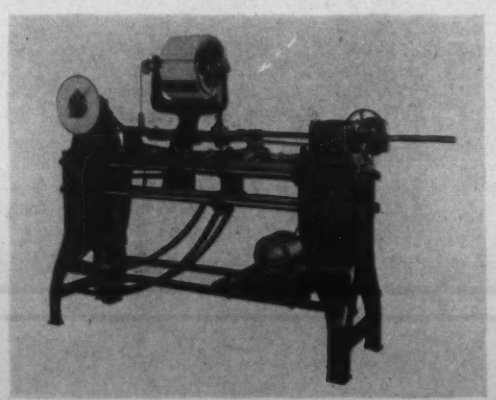

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Radiography of Magnesium Castings

Experience with X-ray Testing of Magnesium Castings for Operating Control and Acceptance Testing ("Erfahrung mit der Röntgendurchstrahlung von Magnesiumguss für Betriebskontrolle und Abnahme") A. H. F. Goederitz. *Giesserei*, Vol. 28, May 16, 1941, pp. 217-224. Descriptive.

Although X-ray examination of aluminum and aluminum alloys are made as a routine practice, radiography as applied to magnesium castings has not given as satisfactory results. Segregations, blisters, holes and pipes can be as easily detected as in aluminum, but the salt inclusions often found in magnesium castings offer only light contrast in the X-ray picture, as their density is about the same as that of magnesium.

Attempts were made to find a satisfactory practice and set-up for routine operations —both visual and photographic. The results, based on study of different intensities (voltages) of the X-ray tubes, focal distances and shapes of the X-ray source, indicate that improvement is definitely possible.

For example, better results can be obtained with a soft (low voltage) source. Also, a point-like source gives sharper pictures than a larger source. Large distances, about 3-4 ft. for visual inspection (on a screen) or 6-10 ft. for photography, are preferable. Ha (4)

Testing Spot Welds

"Methods of Testing Spot Welds." R. E. Bowman (War Dept., Air Corps) *Am. Welding Soc.*, Paper, Oct. 1941 meeting. Descriptive review.

The policy of the Materiel division with respect to the inspection of spot welds is to specify *results* rather than methods or equipment to be employed. The inspection of spot welds is accomplished by tests on single spot lap welds and by radiographic and metallographic examination. Requirements have been established for the strength of the single spot lap weld and also for the soundness of the spot weld.

The twist test and the U tension test have been useful in determining the relative ductility of spot welds in different alloys. In the tests of spot welds in aluminum alloys, some degree of correlation was found between the twist test and the U

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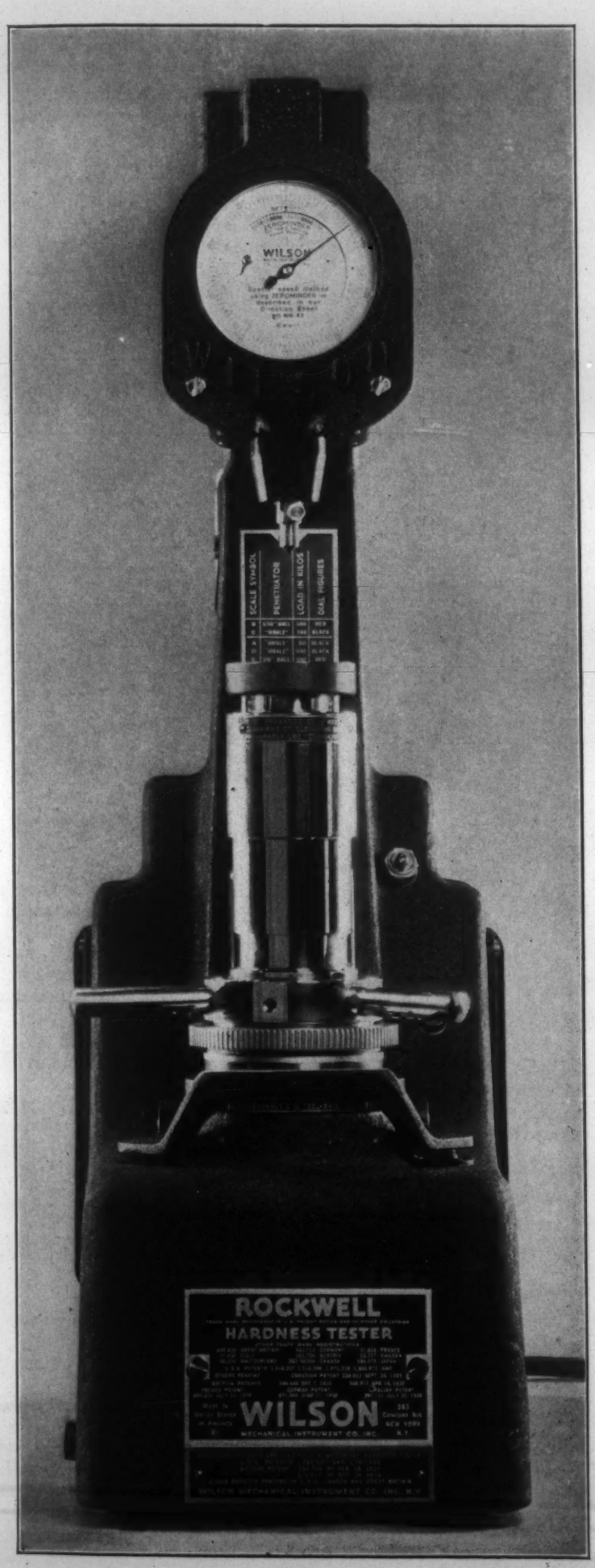

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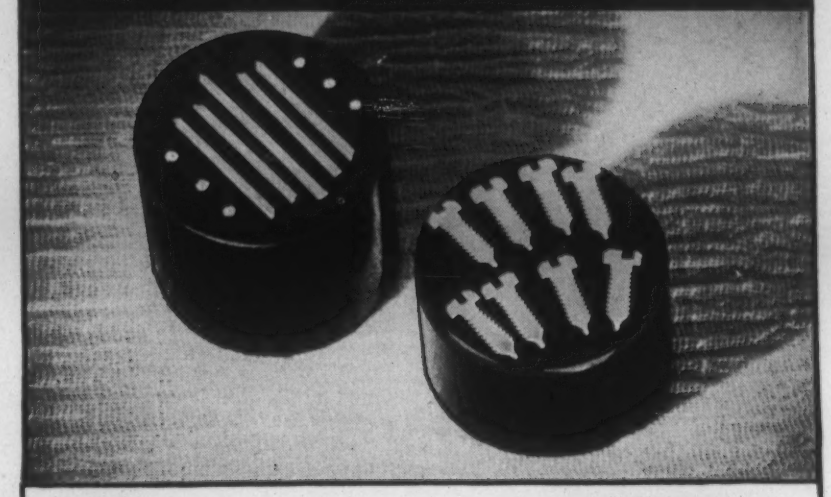

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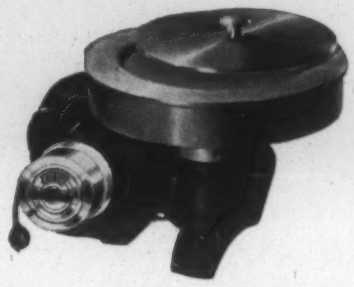

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tension test. The ductility can be determined only approximately with these tests.

In the twist test, the failure does not always occur in the weld metal. In some tests, the failure will occur in the base metal surrounding the spot weld. The result in the U tension test is affected by the amount of bending that occurs when the spot weld is tested.

The corrosion resistance of the spot welds is compared by exposing spot welded panels on the racks in tidewater. In this test, the panels are alternately immersed in the salt water during the high tides and exposed to the atmosphere during low. The length of exposure is usually from 6 months to 1 year. After exposure, the spot welds are examined visually or tested to determine the loss in strength.

The results of tests on spot welded fatigue specimens are not considered satisfactory since they did not furnish any information on the extent to which spot welding can be used in aircraft. The most successful procedure has been to conduct static, vibration and service tests on spot welded parts of airplanes. (4)

Impact Test Specimens

A Composite

Dissatisfaction with the use on brittle steels of the international standard Charpy specimen has led the Swedes, among others, to investigate specimen modifications that might be more satisfactory. Two papers in a recent issue of *Jernkontorets Annaler* present some thought-provoking though somewhat inconclusive results.

A new specimen for the impact test is described by AXEL WAHLSTEEN (Undersökningar av en ny provstavsform för slagprov," *Jernkontorets Ann.*, Vol. 125, No. 6, 1941, pp. 217-248). The purpose of the investigation was to determine if a test specimen with incomplete key hole notch (drilled but not slotted) would prove more satisfactory for brittle steels than the I. S. A. Charpy specimen, without any intention of using it for steels of higher impact strength.

Nine different test specimens were used in the investigation, each 55 mm. long and 10 mm. square. Holes of 3, 4 and 5 mm. diam. were used. The individual specimens were designated by 3-digit numerals as follows: 631, 541, 451, 532, 442, 352, 433, 343 and 253.

In this designation, the first figure denotes the distance from the impact surface to the periphery of the hole, the second figure the diam. of the hole, and the third figure the distance from the periphery of the hole to the surface opposite to the impact surface. (The sum of the 3 figures is thus always 10). Specimen 631, therefore, has a 3 mm. hole placed 6 mm. from the impact surface and 1 mm. from the opposite surface.

The tests were carried out at room temperature (68° F.) with a 30 kg. Charpy pendulum hammer. Specimen 451 showed the smallest variations in the results obtained, and was distinctly superior to the Charpy specimen, in the case of steels with low impact strengths. Specimens 631, 541, 451, and 532 proved superior to the Charpy specimen, except at high impact values.

As a general conclusion, it may be stated that the new specimens showed less variations than the Charpy specimen in all ranges, that all gave better results for brittle steels, and that some even proved equally satisfactory for medium tough steels. Specimens 631 and 541 are recommended as the best, and of these two, No. 631 seemed to have a slight advantage.

Comparative tests between specimen 532 and the Charpy specimen were also carried out between 400° F. and —40° F. Very little difference was found in the two cases. One difference was that the transition from tough to brittle fracture shifted to lower temperatures for specimen 532.

Another approach is the use of the tensile impact test with a notched specimen *of suitable shape*. K. G. OLSSON ("Slagsträckprovet och dess användningsmöjligheter," *Ibid.*, pp. 249-274) presents a review of the current status of the tensile impact test, the tensile test, and the impact test.

It was found that the unnotched specimens gave very poor distinction between tough and brittle steels. Notched specimens of suitable shape gave good results in this respect, and proved more satisfactory than specimen 532 developed by Wahlsteen [and described above].

The notched specimen selected was 12.5 mm. long between shoulders, 7 mm. diam., with a 1 mm. deep notch, 60 deg., running all around the specimens. The shoulders were 14 mm. diam. and 6 mm. long, and the ends beyond the shoulders 10 mm. diam. and the ends beyond the shoulders 10 mm. diam. and 15 mm. long. The unnotched specimen was of similar design, except that the central unnotched section was 5 mm. diam. BHS (4)

New Smoothness Tester

"A REFLECTOMETER FOR MEASURING THE SMOOTHNESS OF METAL SURFACES." BERNARD FRIED. *Eng. Exp. Sta. News*, Ohio State Univ., Vol. 13, Oct. 1941, pp. 10-14. Descriptive.

Most instruments for measuring the smoothness of metal surfaces are designed to measure a particular parameter of smoothness. Optical measurements of the reflection characteristics of metal surfaces tend to give a more or less average effect of all the various factors that contribute to roughness. A modified form of the integrating sphere type reflectometer was built to measure surface quality in terms of reflection properties.

In the usual sphere type reflectometer, the sample forms a relatively small portion of the wall of a hollow sphere. The interior of the sphere is coated with a good diffusing material. A narrow beam of light, projected into the sphere, illuminates directly a small spot on the wall. The first reflected light from the wall is screened from the sample and the photocell, which is the measuring unit. Assuming the sphere wall to be a perfect diffusor, any one element of the sphere illuminates all other elements equally. Thus, relative amounts of reflected light are measured.

The modification of this particular instrument consists in providing means for either retaining or rejecting the light, which is specularly reflected from surface of the specimen. Hence, the instrument will measure in one case the total light, I_t, reflected by the specimen and in the other the diffused light, I_u, reflected by the specimen. The specularly reflected light, I_s, is equal to the difference of the two measurements. The smoothness of the surface will be given as follows:

$$\text{Smoothness} = k \frac{I_s}{I_t}$$

The apparatus is simple, easy to operate, and only two readings are necessary to specify the surface. HRC (4)

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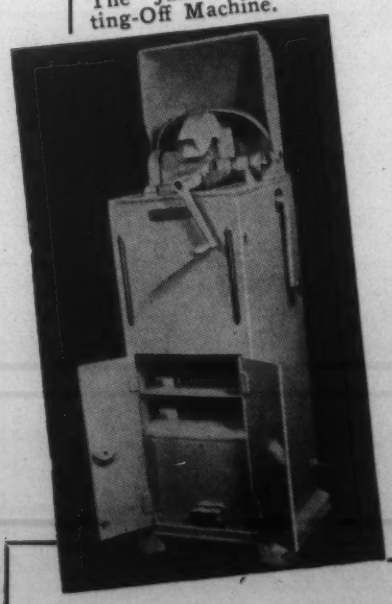
No substitute for consistent results is ever necessary when metallurgical specimens are prepared by the Jarrett method . . . Exact multiple specimen uniformity is assured by the "Grind-Polish" action of special stone laps used in the Jarrett Polishing Machine. Operating technique of the machine itself is so simple that inexperienced operators can produce large quantities of perfectly standardized, high quality specimens in a few minutes.

The Jarrett Cutting-Off Machine.



The Jarrett Technique of preparing Metallurgical Specimens consists of these three brief steps:

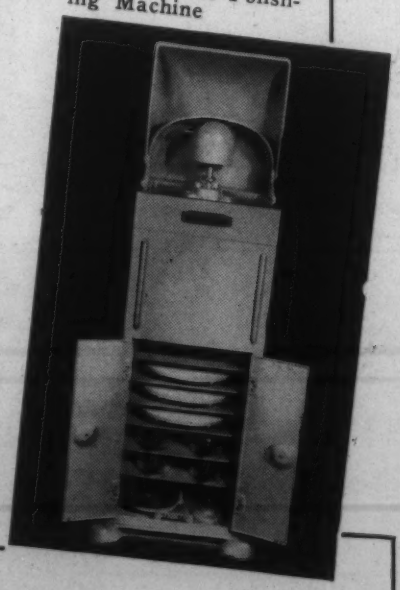
1. Proper cutting of the specimen so that further preparation prior to mounting is eliminated.

2. The freshly cut specimen is mounted in Bakelite or in one of the new prepared mounting rings — further preparation for polishing is unnecessary.

3. Specimen is ground and polished simultaneously using the standard technique established for the machine.

Write for the full details!

The Jarrett Polishing Machine



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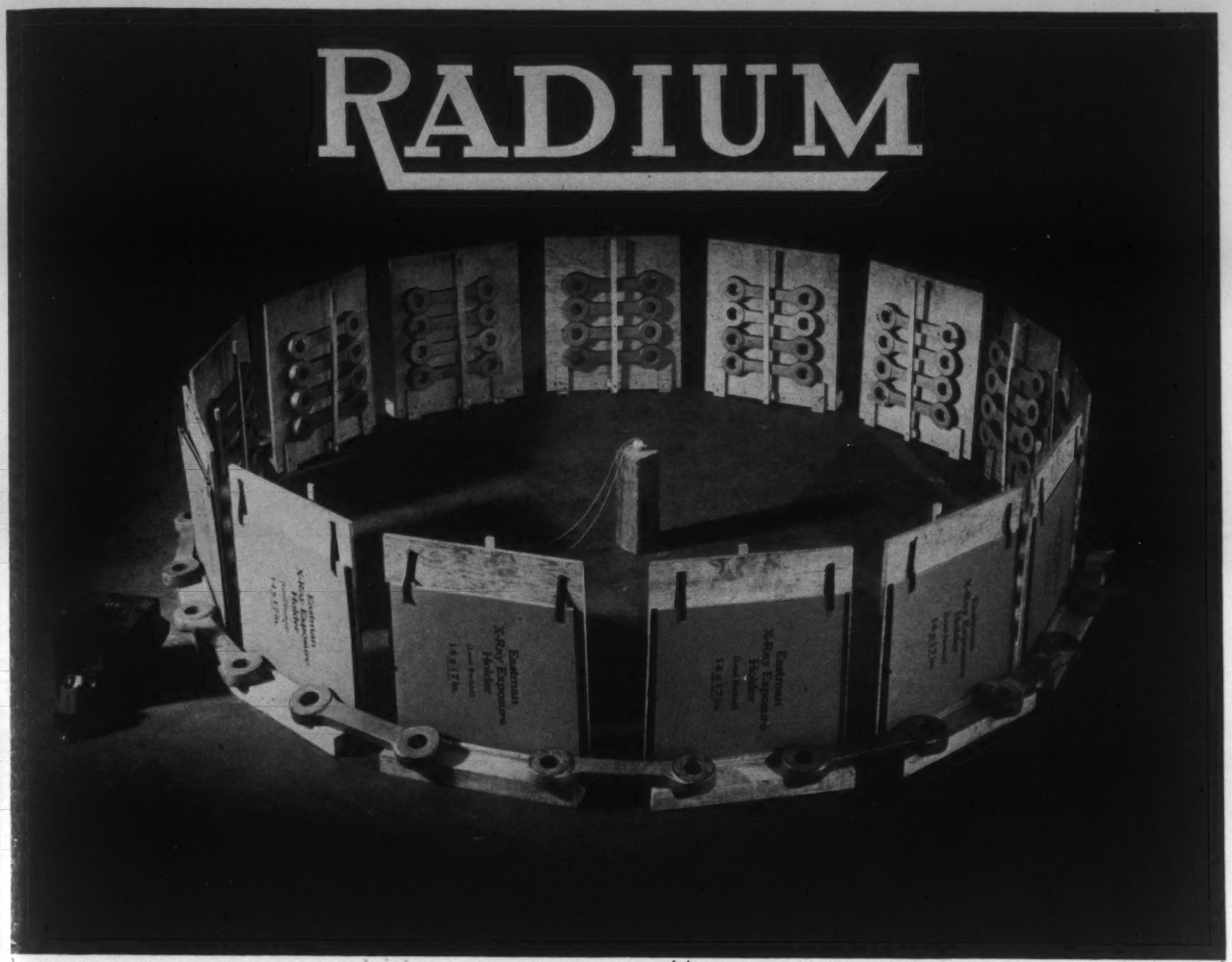

Photograph courtesy of Crane Co.

In the RADIUM RADIOGRAPHY set-up shown above, simultaneous exposures are being made with one radium capsule to 56 parts.

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books

Mechanical Testing and Inspection

THE TESTING AND INSPECTION OF ENGINEERING MATERIALS. *By Harmer E. Davis, George E. Troxell & Clement T. Wiskocil. Published by McGraw-Hill Book Co., Inc., New York, 1941. Cloth, 7¼ x 10¼ in., 372 pages, lithoprinted. Price $3.50.*

The title page of this book states that it is a preliminary edition for use in engineering defense training courses. It should be of great value to young engineers —and to old ones as well—who are entering the greatly expanded field of inspecting and testing materials for use in the various projects of the National Defense Program. The book deals with the mechanical testing and inspection of materials, with notes on certain magnetic and electrical methods used in determining mechanical properties and defects.

It is especially noteworthy in the emphasis placed throughout its pages on the significance of test results and inspection practices. The following quotations, taken from the highly valuable opening chapter, illustrate this feature:

"The ideal test should be meaningful, reliable, reproducible, of known precision, and economical. The selection of a procedure should be controlled by the significance of the test, guided by economy of effort, and influenced by a sense of proportion."

"An experiment or test is unfinished until it is summarized, checked and interpreted."

In this book are discussed the important phases of mechanical testing:—General features of mechanical testing, testing machines, strain-measuring apparatus, gages, tension, compression, shear, torsion and bending tests, tests for ductility, hardness tests of various kinds, impact tests, fatigue tests and creep tests, and non-destructive tests. Emphasis is placed on the necessity for training and experience before reliable results can be obtained with delicate apparatus, and discussion of both simple and elaborate test methods is given, with evaluation of different methods for different problems in testing.

A chapter on Analysis and Presentation of Data gives an introduction to the quantitative interpretation of precision and errors. This should be one of the most valuable chapters in the book, especially for engineers interested in the use of test data as a basis for design. In this connection it may be noted that the book distinguishes between the significance of tests for acceptance of material and of tests to obtain fundamental constants of strength or stiffness for design. The distinction between testing and inspection is also made in this book, although it is acknowledged that these two fields often overlap.

Part II of the book gives detailed instructions for 21 different tests. An appendix giving a summary of average properties of materials is of value, especially if it is recognized that the tabular values of strength are averages, and that a considerable range of variation must be expected in practice. A second appendix giving several hundred references opens the door to further information for any testing engineers —young or old—who have the ambition and the energy to seek it.

"Testing and Inspection of Engineering Materials" is a most timely book.

—H. F. MOORE

TRUE STEEL. *By C. Borth. Published by Bobbs-Merrill Co., Indianapolis, Ind., 1941. Cloth, 6 x 8½ in., 319 pages. Price $3.00.*

This is Mr. Borth's story of G. M. Verity and The American Rolling Mill Co. It is a story of a man and a company whose initial assets—the proverbial shoe string, in comparison with the industrial giants of the day—were developed with vision and sound technological execution to produce the powerful organization that Armco is today.

Over these years, Armco has to its credit important developments in steel making and has seen its continuous process for rolling strip become the dominant factor in peace time production of flat stock for auto bodies, refrigerators, stoves, and the like, and in the military production of important sinews of war. In the driver's seat was Mr. Verity, ever on the alert for new ideas with which to build up his organization. It is of interest to technical men that he looked not to competitors to copy and thus to keep abreast of the times, but always sought new markets or better methods and improved products. Having spotted a promising idea, it was then up to the technical departments to carry out the details.

An attribute of a great leader is that of being able to select good men and keep them productively at work. In this Mr. Verity showed genius, as is exemplified by the author's vivid picture of the struggles with production and development work. The development of "Armco Ingot Iron" of 99.84% purity was an outstanding achievement.

Details of these and other technological developments are recorded but particular emphasis is placed on the theme first stated in 1905—"Someday we'll be making sheets in long strips like they make paper." For years this idea of continuous-rolling sheet was considered: dreams dreamed, plans laid, money appropriated,—and actual work postponed.

In the nineteen-twenties the Ashland plant was acquired and soon thereafter actual development work started in earnest. The appropriations were so large that even at that late date the future of the company was placed in jeopardy and the experiments simply had to succeed. The ultimate success of this venture is history and in later years every major steel producer has installed continuous mills with electric drive for the production of sheet and strip.

The social implications of Mr. Verity's work are the really dominant theme of the book. It was his attitude toward his workmen and fellowmen and his practical philanthropy that rates his hero as "true steel' in Borth's eyes. In spiritual values he rounded out his contribution by seeing to it that his people had recreation centers, playgrounds, athletic fields, parks, concerts, and even well-built homes. The greatest value of the book is as a lesson in personal relations.

The technical reader should take this book as an historical biography and be prepared to overlook a few slips in factual accuracy. They have no important bearing on the main theme and none at all on the rating of Mr. Verity and his associates as "true steel."

—S. L. HOYT

Copper in Iron and Steel

COPPER IN TECHNICAL IRON *(Kupfer in technischen Eisen). By Heinrich Cornelius. Published by Julius Springer, Berlin, 1940. Cloth, 6½ x 9¼ in., 225 pages. Price 28.50 RM.*

The author, familiar to many through his numerous contributions to various German technical publications, does a creditable job of compiling the literature on the use of copper in iron and steel.

The book covers the use of copper in wrought steels, cast steels, cast iron, and malleable iron. The portion on steel is fairly comprehensive; however, one might wish to see the section on high-alloy cor-

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When a peace-time tomorrow arrives, the steels which enable us to build faster warplanes, stronger tanks, guns and battleships will mean safer, swifter transport and private airplanes — finer automobiles, trucks, railroad trains and machinery — even better washing machines, refrigerators, stoves and thousands of other products in which steel makes life more livable, more comfortable, more enjoyable.

And when that tomorrow comes, Republic will be ready to produce these steels in quantities sufficient for everyone.

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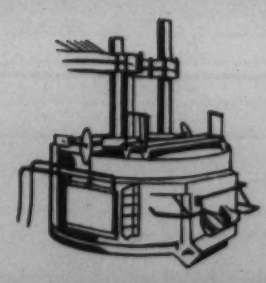
Anticipating the growing need for electric furnace steels, Republic has increased its electric furnace capacity approximately 500% in the last two years.

IN 1939
146,000 TONS ANNUAL CAPACITY

IN 1941
720,000 TONS ANNUAL CAPACITY



rosion resisting steels expanded somewhat. The author's coverage of the use of copper in cast and malleable iron, on the other hand, hardly seems adequate.

This book is definitely more readable than "The Alloys of Iron and Copper" and has much better arrangement than "Copper in Cast Steel and Iron," although comparatively little new material has been added. In English it would be a welcome addition to a technical library, but in German it is hardly worth the effort, or the price.

—R. E. Adams

Steel Strip Mills

The Modern Strip Mill. *Published by Association of Iron & Steel Engineers, Pittsburgh, 1941. Cloth, 9 x 12 in., 512 pages; plus 33 plant layouts. Free to A. I. S. E. members, $15.00 to others.*

Although this new volume appears at first glance to be a "buyer's catalog" of materials and equipment used in steel strip mills, inspection reveals that the inclusion of over 250 pages of worthwhile "editorial" material has made the book something more than a collection of descriptive advertisements.

The volume is divided into two major parts. The first comprises 9 sections on equipment, operations and processes used in modern strip mills, the section titles being "General," "Slab-Heating," "Hot Strip Mills," "Mill Parts and Accessories," "Electrical Equipment," "Pickling," "Cold Mills," "Heat Treating," and "Processing and Material Handling." Each section contains text material reviewing the subject and presenting much specific descriptive material, and includes advertising pages.

Taken as a whole, the 145 pages of editorial material in this first part represents one of the best practical descriptions we have seen of general strip mill equipment and practice.

The second part of the book is given over to detailed descriptions of the layout and equipment of 33 large strip mills, evidently as published in past issues of *Iron & Steel Engineer.*

The whole enterprise is a real service to the steel mill engineer.

—Fred P. Peters

Steel Wire

Steel Wire (Stahldraht) *By A. Pomp. Published by Stahleisen, Düsseldorf, 1941. 6¼ x 9 in., 275 pages. Price 17 RM.*

In spite of war conditions, Stahleisen (the publishing department of the German Iron and Steel Institute) has undertaken the publication of an extended series of comparatively small books on well circumscribed subjects (in German).

This volume is the first. It begins with properties of the hot-rolled rod and ends with testing the finished wire. All intermediate stages and processes are described in detail. The book is a happy mixture of sound theory and advanced practice, as far as the latter has been released for publication.

Those readers who are well versed in the manufacture of steel wire may possibly miss information on extremely specialized details here and there, but the average reader will find his every question answered in theory, engineering, metallurgy, and operation. There are important chapters on pickling, drawing, annealing, patenting, hardening, coating and testing.

An interpretive translation of the volume by an American expert in steel wire is very much to be desired. If the forthcoming books of the series are as good as the first volume, they will make an interesting shelf of books for the steel industry.

—W. Trinks

Metal Inspection

Inspection of Metals. *By Harry B. Pulsifer. Published by American Society for Metals, Cleveland, Ohio, 1941. Cloth, 6¼ x 9¼ in., 180 pages. Price $1.00.*

In attempting to prepare a small volume for the use of those learning to inspect metals, the author of this book has of necessity been obliged to treat the subject somewhat superficially in order to cover the field considered and yet comply with the size of text limitations imposed. As indicated in the Preface, the information applies rather closely to the non-ferrous metals. Experience in actual inspection work will of course reveal many differences in practice from procedures described.

Perhaps the purpose of the booklet would have been better served if the author had adhered more closely to generally accepted standard methods of testing as given in current metal specifications, particularly those of the various government departments, the A.S.T.M. and the A.S.A.

Chapter X, "Coatings and Corrosion Testing" is specifically concerned only with metallic coatings and corrosion of metals. In this same chapter the salt spray testing device described is not in keeping with present A.S.T.M. Standards. These are but examples of perhaps minor points of information that may lead to misunderstanding or misinterpretation on the part of the reader unless the details are further investigated.

Irrespective of the brief criticisms indicated, it is believed that this book may well be found useful to the beginners in the metal inspection field and should serve to stimulate their desire to study the subject in further detail.

—R. L. Templin

Hand-Working of Sheet Metal

Sheet Metal Work. *By E. Molloy. Published by Chemical Publishing Co., Brooklyn, N. Y., 1941. Cloth, 5¾ x 8¾ in., 96 pages. Price $2.00.*

This is Vol. 7 in the "Complete Engineer" series, written in England, though this last fact is not brought out save by the spelling *aluminium* and references to British tools, etc. It is a shop-procedure handbook for forming sheet metal by hand and with simple hand-operated tools. Four pages on soldering and two on welding are included.

It contains no "metallurgy" aside from five pages of very sketchy description of sheet metals. With the copious illustrations, it might be useful in a high school industrial arts course, but has no bearing on quantity production problems.

—H. W. Gillett

Mineral and Metal Statistics

Minerals Yearbook—Review of 1940. *Published by U. S. Bureau of Mines, Dept. of the Interior, Washington, D. C., 1941. Cloth, 6¼ x 9¼ in., 1459 pages. Price $2.00.*

Demand for information on metals, nonmetals and minerals has been so insistent, due to present economic and other conditions that this volume has been published more than three months in advance of last year's date. It contains a great deal of comprehensive information and many data—"the most inclusive collection of facts and statistics on mineral industries ever assembled."

A quick appraisal tends to justify the above claim. A classification has been adopted which is advantageous—all the minerals arranged as strategic or critical.

Two new chapters appear. One is a "Review of Mineral Industries in 1940," which presents a summary of the principal developments during the year. The other one is entitled "Effect of the International Situation on United States' Trade in Minerals."

—Edwin F. Cone

Other New Books

Index to the Literature on Spectrochemical Analysis. 2nd Edition. 1920-1939. *By W. F. Meggers & B. F. Scribner. Published by Am. Soc. Testing Materials, Philadelphia, 1941. Paper, 6 x 9 in., 94 pages. Price $1.00.* Over 1400 references to publications on spectroscopy and spectrography grouped chronologically, but with a detailed subject index.

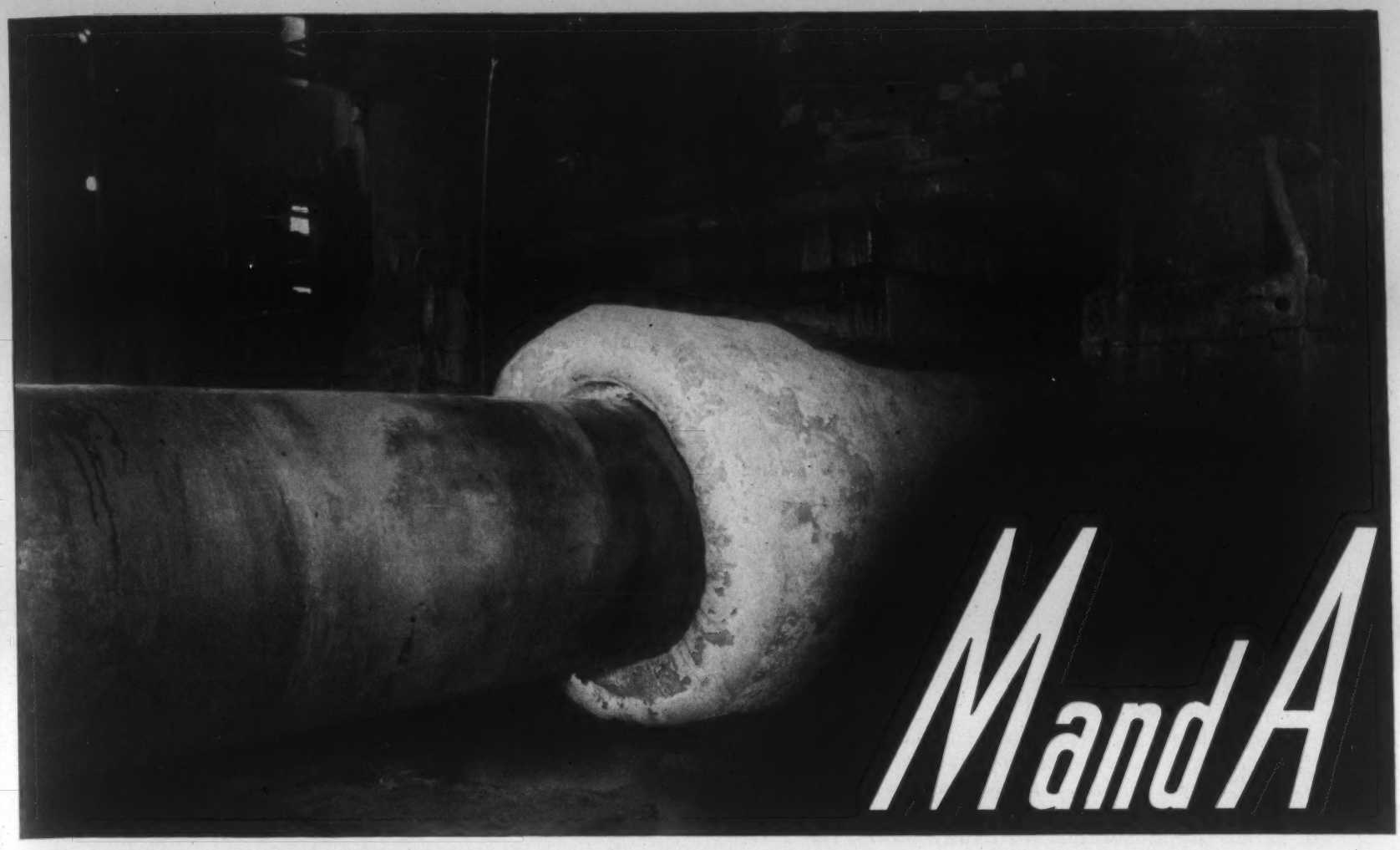
Aerosphere—1941. *Edited by Glenn D. Angle. Published by Aircraft Publications, New York, 1941. Cloth 9 x 11¾ in., 957 pages. Price $10.00, plus shipping charges.* The second edition of this world-wide aviation reference annual, through the omission of certain historical and other material, is some 500 pages thinner and $5.00 cheaper than the first edition, reviewed in Metals and Alloys, Vol. 12, Nov. 1940, p. 706. Descriptions of all types of aircraft and engines, industry statistics and a buyer's guide make this volume at least as useful as its predecessor.

The Reference Library of the Welding Research Council. Section 1—Classified Library Catalogue. *Published by Institute of Welding, London, 1941. Paper, 5½ x 8½ in., 136 pages. Price 2s/—d.* A bibliography of several hundred books, reports and manuscripts (not magazine articles) on welding, collected by the Institute since 1923. A bibliography of recent periodical publications will appear later.

Bibliography on Induction Heat Treatment. *Published by Engineering Societies Library, New York, 1941. Paper, 9 x 11¼ in., 5 multigraphed pages. Price $1.25.* Forty papers are listed, dealing with metallurgical factors, design of heating coils and circuits, and typical installations.

Handbook of Sleeve Bearings. *By Albert B. Willi. Published by Federal-Mogul Corp., Detroit, Mich., 1941. Cloth, 6¼ x 9¼ in., 230 pages. No charge to directly interested engineers.* This consists mainly of tables of dimensions of sleeve bearings of different types obtainable from Federal-Mogul, but also contains useful comment on clearances, corrosion, oil grooving, the use of shims, etc. Three-layer (steel-bronze-babbitt), sintered copper-lead, and aluminum-tin bearings are listed, too.

Facts for Foundrymen. *By E. G. Jarvis & H. O. Jarvis. Published by Niagara Falls Smelting & Refining Corp., Buffalo, 1941. Cloth, 4 x 6¼ in., 76 pages. Price $1.00.* Much handbook-type reference material makes this more than mere advertising.



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trends

By Edwin F. Cone, Editor

Copper—"A Precious Metal"

Copper is becoming "a precious metal today" says Robert E. McConnell, director of the conservation section of the O.P.M. "Despite a record increase in domestic production and despite large imports from South America, there will be less copper available for civilian use by Jan. 1 of next year than was used in 1933, the worst year of the depression; and by July 1, 1942, there will be even less." It may be necessary to find a substitute for the millions of extra pennies that are necessary to pay certain minor or nuisance taxes.

Air Conditioning Blast Furnaces

Air conditioning equipment offers the steel industry the most attractive means of increasing iron production in the interest of National Defense and the equipment can be installed in a comparatively short time compared to building additional furnaces or beneficiating raw materials to increase production, says E. K. Miller, assistant general superintendent, Aliquippa Works, Jones & Laughlin Steel Corp., in an article in *Steel*, Nov. 10. There is a decided trend towards the air conditioning of blast furnaces.

Air-Conditioning of Plants

The largest air-conditioning system ever installed in an American industrial plant is in the new Ford $23,000,000 plant for producing Pratt & Whitney aircraft engines. The system will handle 2,000,000 cu. ft. of air per min., changing the air inside the plant every 10 min. The trend towards the air conditioning of industrial plants reaches a high point in this installation.

Saving Tin

A research program is being undertaken by the Monsanto Chemical Co. looking to the application of a phosphoric acid or phosphate treatment to rolled steel strip used in making cans. If successful, this would remove the necessity of applying tin to the inside of cans.

Aluminum in Steel Making

About 30,000 tons of aluminum each year, at the present rate of operations, are needed by the American steel producers, chiefly to deoxidize and purify molten steel. The use of this metal for these and other purposes in the manufacture of steel has expanded markedly in the last few years. No substitutes that are satisfactory are available in sufficient quantities.

However, secondary aluminum, so impure as to be of no use on aircraft or other defense work, serves nicely for use in steel. The impression carried by superficial comments, that supplying the need for aluminum in steel means less aluminum for bombers, is wholly erroneous.

Less Spiegeleisen

The sharp decline in the output of spiegeleisen in the first half of this year as contrasted with the rates for the two half years of 1940 is surprising. The production for the first half of this year was only 75,376 net tons or about 12,560 tons per month. In the first half of 1940, the rate of output was 21,500 tons each month with 17,900 tons monthly in the last half, or the 1940 rate was about 19,700 tons per month which contrasts with only 12,560 tons each to July 1 this year.

The production of ferromanganese, ferrosilicon and "other ferroalloys" shows higher volumes this year.

Our Steel Needs

Based on statistics of actual shipments of steel to major industries in recent years and during the first quarter of 1941, checked against analyses of expected demand from such sources in the remainder of 1941, the requirements for this year for defense, domestic civilian use and for export total approximately 80,000,000 net tons of steel ingots. This is about 95 per cent of the industry's capacity as of Jan. 1, 1941, according to a study by the committee on commercial research of the American Iron and Steel Institute. Since the first of this year our ingot capacity has increased. According to these statements the suggestion of an increase in our capacity of some 10,000,000 to 15,000,000 tons seems unjustified.

Saving Manganese

The desire to save manganese in steel making is on the way to realization. According to a report of an informal committee of metallurgical engineers, selected from the technical committees of the American Iron and Steel Institute, made to the National Academy of Sciences, it is estimated that "an immediate saving of about 10 percent from average amounts of manganese used heretofore can be made without undue hardship, but that no more than 20 per cent can be saved without serious effects on both production and use of steel products."

Electric Steel

The country's electric steel capacity was recently increased by about 100,000 tons annually by the installation of a 70 and a 30-ton furnace at the South Chicago, Ill., works of the Carnegie-Illinois Steel Corp. This and installations by other steel companies are gradually expanding this branch of the country's steel-making capacity.

(Additional "Trends" on page 964)

A few of the basic *individual* characteristics of both Cast Iron and Steel are listed. ***MEEHANITE*** castings offer you, through composition and structural control, a *combination* of these properties, permitting simplification of design and demanding no sacrifice of one in order to be assured of another.

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Irvington, N. J.	Barnett Foundry & Machine Co.
Los Angeles, Calif.	Kinney Iron Works
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New York, N. Y.	The American Brake Shoe & Foundry Co.
Oakland, Calif.	Vulcan Foundry Company
Orillia, Canada	E. Long, Ltd.
Philadelphia, Pa.	Florence Pipe Foundry & Machine Co., (R. D. Wood Company, Selling Agents)
Phillipsburg, N. J.	Warren Foundry & Pipe Corp.
Pittsburgh, Pa.	Meehanite Metal Corporation
Pittsburgh, Pa.	Rosedale Foundry & Machine Co.
Rochester, N. Y.	American Laundry Machinery Co.
St. Louis, Mo.	Banner Iron Works
St. Paul, Minn.	Valley Iron Works
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Waterloo, N. S. W.	Australian Meehanite Metal Co., Ltd.
Johannesburg, South Africa	Meehanite Metal Co. (S.A.) (Pty.) Ltd.

trends

By Edwin F. Cone, Editor

Magnesium Supply and Demand

According to present estimates, the supply of magnesium in 1942 will be far less than the demand. For flares and incendiary bombs for aircraft there will be needed about 80,000,000 lbs. with the estimated output only 60,000,000 lbs., said Harvey A. Anderson of the O. P. M. in a recent address. If defense, lease-lend, and civilian needs are taken into consideration, the demand will approximate the startling total of 14 times the estimated 1942 production, or over 400,000 tons.

Alloy Steel

The desired requirements of alloy steel for 1942 are estimated at 12,000,000 net tons, according to a recent statement by Maxwell Brace, head, alloy steel section, Iron and Steel Branch, O. P. M. In 1941 the total will be about 9,000,000 tons or 11 per cent of the total steel production. In 1929 the alloy steel output was 4,432,000 tons or 7 per cent of the total, while in 1940 the 4,965,000 tons was 7½ per cent. The recent expansion is impressive.

Aluminum in Steel Making

Aluminum consumption for the deoxidation of steel declined from a rate of 0.698 lbs. per ton of steel ingots produced in the last half of 1940 to 0.562 lbs. per ton in June 1941, according to a report of metallurgical engineers to the O. P. M. Any further marked decrease will adversely affect steel production, it is stated.

The decrease effected in aluminum consumption so far this year was accomplished through the general substitution of other deoxidizers, in many cases more expensive than aluminum.

More Machine Tools

Mason Britton of the O. P. M. said in a recent address that the demand for machine tools is so great that "we will need two billion dollars worth in the next two years."

Zirconium

Imports of zirconium ore and sand are skyrocketing. Government reports show that for the first 7 months of 1941, the monthly receipts were at the rate of 4,400,000 lbs. which contrasts with 2,800,000 lbs. monthly in 1940 and with only 572,000 lbs. per month in 1939. Most of it comes from Australia.

A large quantity of this zirconium is being used as an oxide as a substitute for tin in the enameling industry, and a larger amount than formerly is being used in the steel industry.

Cartridge Cases of Steel

Investigations are on foot looking to the successful manufacture or cartridge cases of steel in this country. It is understood that the Germans in World War I used the steel cases and possibly are doing so now. In any event, their employment in this country would release large quantities of copper and zinc for both defense and non-defense purposes.

Substitute Metals in 1942 Autos

Drastic changes in certain parts of the 1942 automobiles have been necessitated by the scarcity of certain metals for the Defense Program. For example, stamped steel is being substituted for zinc die castings formerly incorporated in door handles, grilles, steering post hubs, horn rings, and horns—according to data published by *Product Engineering*. Parts formerly made of aluminum but now of cast iron (or steel) include pistons, cylinder heads, and valve chamber covers.

Ferromanganese

The output of that highly essential ferroalloy—ferromanganese—continues to expand. The 55,495 net tons, made by American blast furnaces in October, is a new high record. The average monthly output for 1940 was about 39,500 tons—to Nov. 1 it has been approximately 44,330 tons per month.

Steel Ingot Output

The remarkable expansion in the steel ingot production of the American steel industry this year is revealed by the statistics for October. A new high monthly record of 7,242,683 net tons was made in that month. For the 10 months the total has reached 68,793,571 tons, which exceeds that of any complete calendar year.

Metals in Radios

Radios for 1942 are likely to be more expensive than present models, according to *Electronics*. Cardboard, metal coated fiber and paper, glass, plastics, and synthetic textiles are probable substitutes for some of the metal parts now in use. In the average set at least 14 metals and alloys are now used: Aluminum, brass, cadmium, chromium, cobalt, copper, iron, steel, molybdenum, nickel, tantalum, tin, tungsten, and zinc.

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. . . AND THEN THEY CALLED IN

THE MAN FROM CARNEGIE-ILLINOIS

A bedspring manufacturer faces the job of producing machine gun clips. A staybolt maker converts his entire production to machine gun barrels. Armor piercing bullets in an endless stream are produced by a gear maker. Heavy caliber shells roll swiftly from a factory that formerly made linoleum rugs.

PICTURE what's been happening to the men in these plants. For them, this swing-over from peacetime manufacture to production for defense, has been one long succession of headaches. In most cases they have had to start from scratch to learn how to turn out, in huge quantities and quickly, a product entirely new and unfamiliar. Often they have had to master equally unfamiliar processes of manufacture.

Even when the tough problems of equipment and personnel had been solved, other questions just as important still remained to plague them: What steel to use? How to get the high physicals demanded? How to meet the exacting standards required? . . . It was then they wisely called in the man from Carnegie-Illinois.

In one plant after another, our steel metallurgists have been able to lend a helping hand. Drawing on their wide experience in the latest fabricating techniques, they have shown how to speed up forging, to save time in welding, to reduce machining schedules. Again and again their suggestions have lead to important modifications in manufacturing methods that have worked wonders in obtaining highly desirable physical properties formerly thought impossible.

This practical advice and cooperation are available to every user of Carnegie-Illinois steels and to every manufacturer of defense materials.

CARNEGIE-ILLINOIS STEEL CORPORATION

Pittsburgh and Chicago

Columbia Steel Company, San Francisco, *Pacific Coast Distributors* · United States Steel Export Company, New York

UNITED STATES STEEL

USS

INTO the flaming furnace of today's urgency are going many products admittedly new. From that furnace will evolve the better implements of tomorrow. Midvale is proud to share in today's urgent efforts, will be still prouder to share in tomorrow's progress.

THE MIDVALE COMPANY • NICETOWN • PHILADELPHIA, PA.

OFFICES: *New York* • *Chicago* • *Pittsburgh* • *Washington* • *Cleveland* • *San Francisco*

MIDVALE

THE WILL TO MAKE GOOD STEEL

MAKING the kind of steel our country demands for its defense program requires a thorough knowledge of the steels needed, an organization of skilled steel makers, the best of steel making equipment, and — above all — the W I L L to make good steel.

The Copperweld Steel Company is producing the following Aristoloy Steels particularly for National Defense: RIFLE AND GUN BARREL QUALITY, GUN QUALITY, SHOT QUALITY, BULLET CORE AND AIRCRAFT QUALITY.

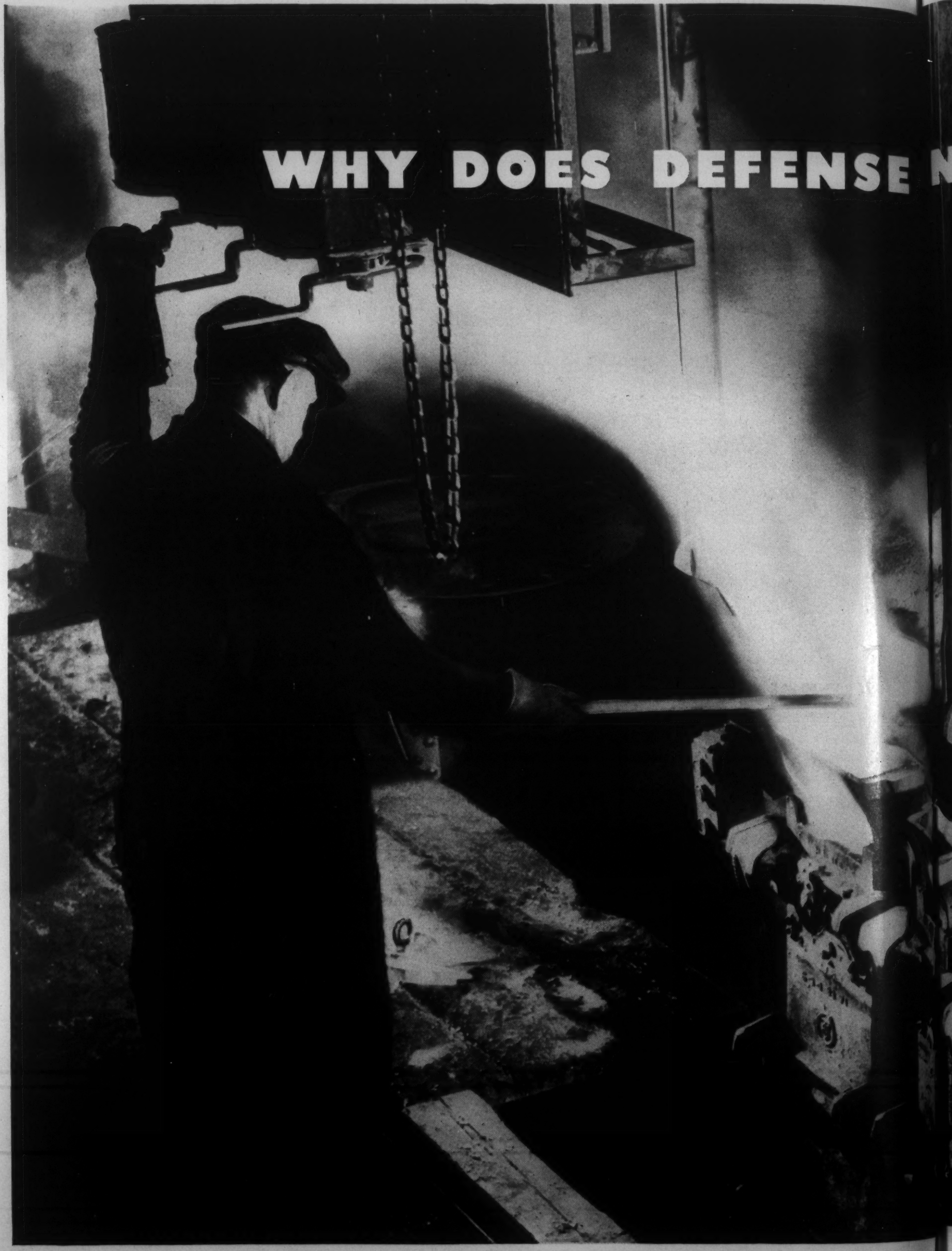
"SPECIAL QUALITY" TOOL AND ELECTRIC FURNACE ALLOY STEELS

CARBON TOOL STEELS
ALLOY TOOL STEELS
STAINLESS STEELS
NITRALLOY STEELS
AIRCRAFT QUALITY STEELS
BEARING QUALITY STEELS

ARISTOLOY STEELS

ARISTOLOY STEELS

COPPERWELD STEEL COMPANY WARREN, OHIO


WHY DOES DEFENSE N

Everdur?

Your steadily mounting regard for this unique copper-silicon alloy is the best answer . . . Uncle Sam, like you, wants its advantages of corrosion resistance, strength and toughness at economical cost!

Filling defense orders for Everdur* is just about a full time job. The properties you have found so useful have also made a hit with defense chiefs, especially for naval work . . . with the result that the demand for Everdur is at an all-time peak.

Should you face delays in obtaining Everdur equipment, here's the reason: the metal is not only being used in large quantity by war-vital chemical plants, but also for fuel lines on airplanes . . . for non-magnetic pilot houses on naval craft . . . for bolts and screws in hundreds of ships' hulls . . . and for many other defense applications where Everdur serves best because of its strength, corrosion resistance, weldability and high endurance limit.

* * *

We are making more Everdur copper-silicon alloys than ever before. But due to the Defense Program, copper is under strict priority and allocation control, and the availability of Everdur for civilian needs is accordingly restricted. In the future, however, this unique alloy will assuredly find ever-widening fields of usefulness.

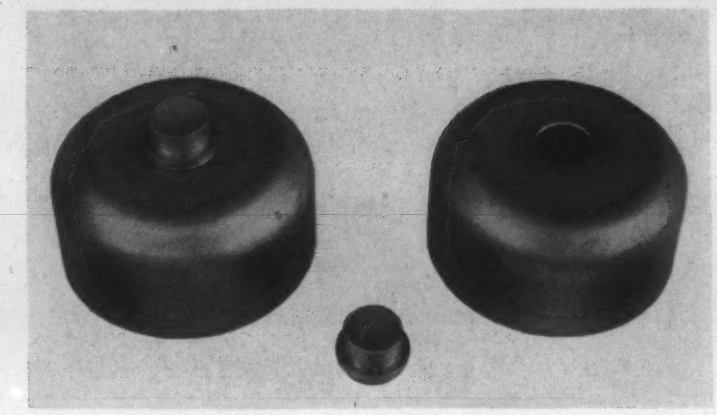
*"Everdur" is a trademark of The American Brass Company, registered in the U. S. Patent Office. 41159A

ANACONDA
from mine to consumer

Everdur COPPER-SILICON Metal

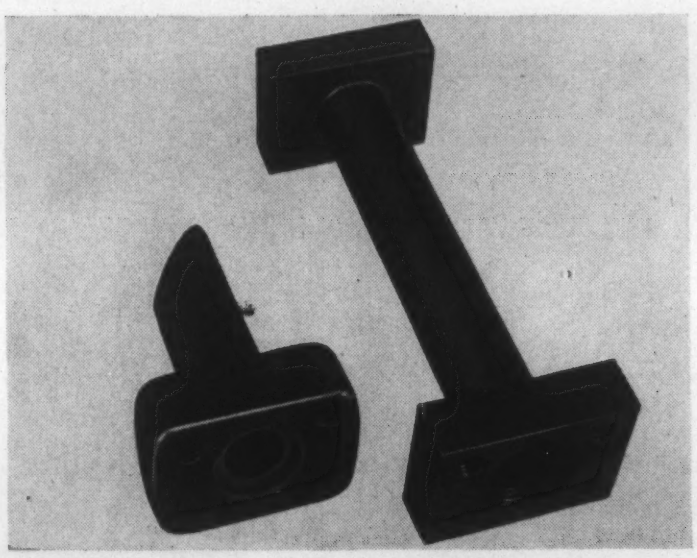
THE AMERICAN BRASS COMPANY—General Offices: Waterbury, Conn.
Subsidiary of Anaconda Copper Mining Company
In Canada: ANACONDA AMERICAN BRASS LTD., New Toronto, Ont.

can ELECTRIC FURNACE BRAZING cut costs similarly for YOU?

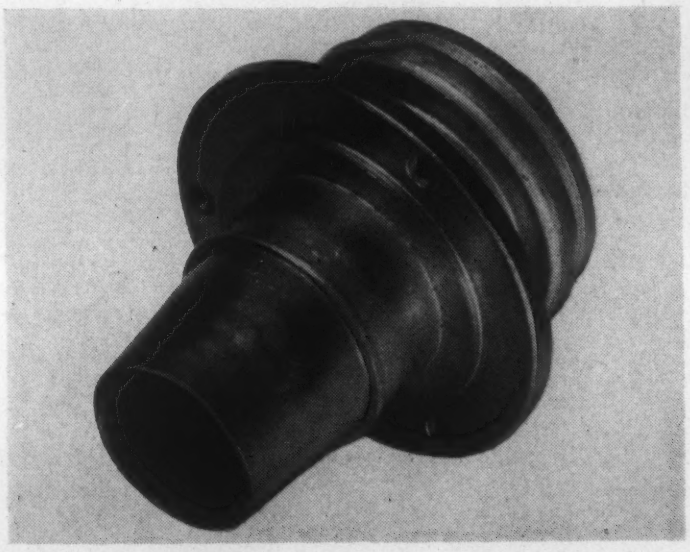


FORMERLY DRAWN, this fan housing is now electric furnace-brazed at a saving of 14½%.

FORMERLY DROP-FORGED, this rocker arm costs 14% less to produce by electric furnace brazing.



FORMERLY CAST—now electric furnace-brazed, this tank spud with 2 gas-tight brazed joints costs 32% less.



FORMERLY MACHINED, this nozzle is now produced with four electric furnace-brazed joints at a saving of 25%.

• • •

Are you using—or producing—expensive castings or machined parts which electric furnace brazing could produce cheaper and better?

This cost-reducing process offers surprising advantages in unexpected places . . . in producing built-up structures at lower cost in place of screw-machine parts, forgings or drawn products . . . in joining metal parts more accurately, cheaply and in quantity.

Where and how *you* may be able to use electric furnace brazing to advantage is explained in a new helpful and informative Westinghouse booklet just off the press. Write for free copy without obligation. Ask for B-3019. Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa., Dept. 7-N.

J-10204

Westinghouse

ELECTRIC BRAZING FURNACES

STAINLESS ELECTRODE WELDING PROCEDURE!

Just off the Press! Arcos Technical Bulletin No. 5. Here is new, concise information in easy-to-use form—including illustrated procedure for welding air hardening steels with Arcos Stainless Electrodes. Write today for your copy.

ARCOS CORPORATION
401 N. Broad St., Phila., Pa.

it's ARCOS for stainless electrodes

"QUALITY WELD METAL EASILY DEPOSITED"

Distributors Warehouse Stocks in the Following Cities:

ATLANTA, GA.	*J. M. Tull Metal & Supply Co.*
BUFFALO, N. Y.	*Root, Neal & Co.*
BORGER, TEXAS	*Hart Industrial Supply Co.*
BOSTON, MASS. (Belmont)	*H. Boker & Co., Inc.; W. E. Fluke*
CHICAGO, ILL.	*Machinery & Welder Corp.*
CINCINNATI, OHIO	*Williams & Co., Inc.*
CLEVELAND, OHIO	*Williams & Co., Inc.*
COLUMBUS, OHIO	*Williams & Co., Inc.*
DETROIT, MICHIGAN	*C. E. Phillips & Co., Inc.*
ERIE, PENNA.	*Boyd Welding Co.*
FT. WAYNE, IND.	*Wayne Welding Supply Co., Inc.*
HONOLULU, HAWAII	*Hawaiian Gas Products, Ltd.*
HOUSTON, TEXAS	*Champion Rivet Co. of Texas*
KANSAS CITY, MO.	*Welders Supply & Repair Co.*
KINGSPORT, TENN.	*Slip-Not Belting Corp.*
LOS ANGELES, CALIF.	*Ducommun Metals & Supply Co.*
MILWAUKEE, WIS.	*Machinery & Welder Corp.*
MOLINE, ILL.	*Machinery & Welder Corp.*
NEW YORK, N. Y.	*H. Boker & Co., Inc.*
OKLAHOMA CITY, OKLA.	*Hart Industrial Supply Co.*
PAMPA, TEXAS	*Hart Industrial Supply Co.*
PITTSBURGH, PA.	*Williams & Co., Inc.*
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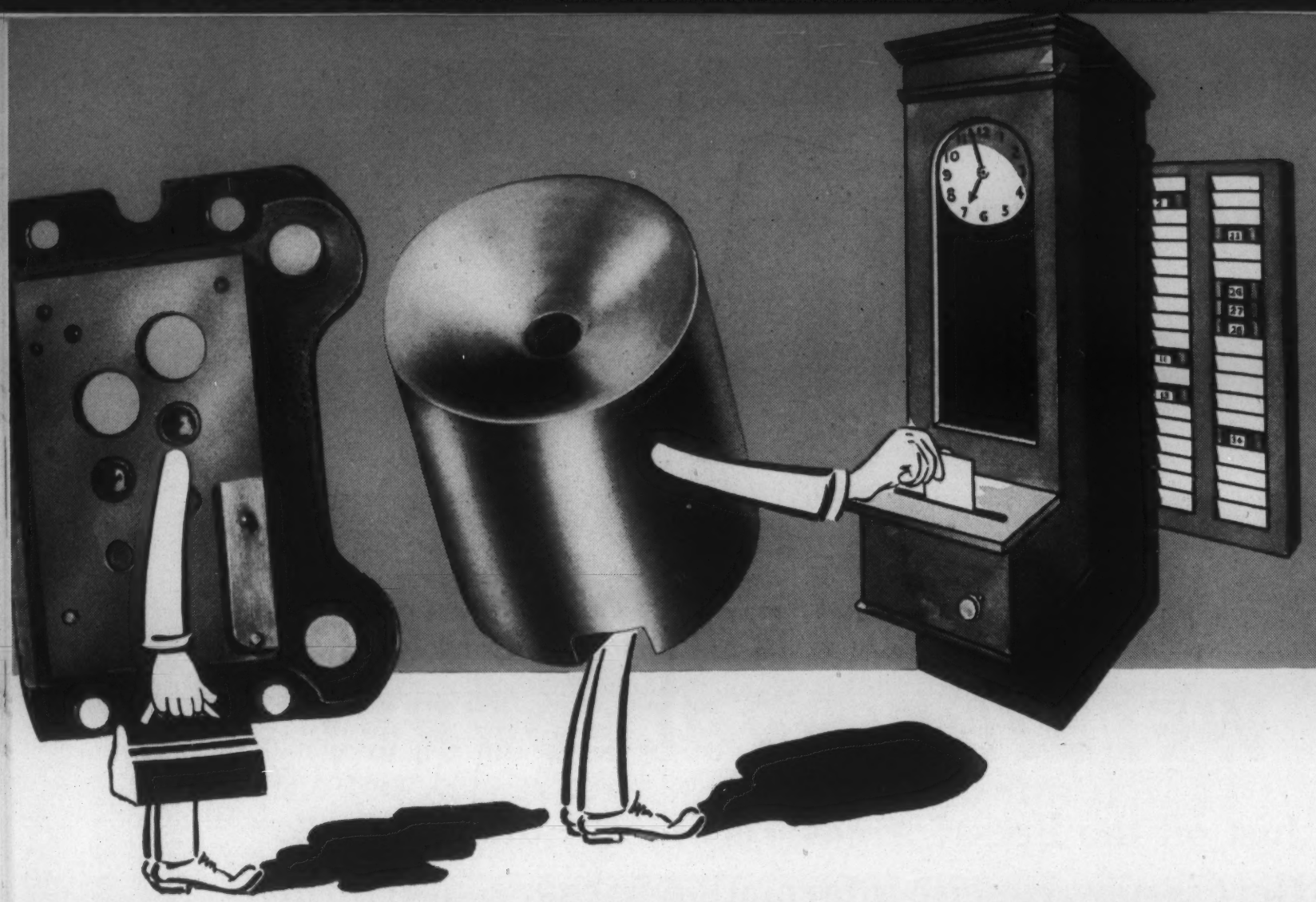
ROCHESTER, N. Y.	*Welding Supply Co.*
SAN FRANCISCO, CALIF.	*Ducommun Metals & Supply Co.*
SEATTLE, WASH.	*H. A. Cheever Co.*
ST. LOUIS, MO.	*Machinery & Welder Corp.*
SYRACUSE, N. Y.	*Welding Supply Co.*
TOLEDO, OHIO	*Williams & Co., Inc.*



TOOLS SHOULD PUNCH THE TIME

If your tools had to punch out every time they were responsible for interrupting machine output . . . you might be startled by their short working time! Right now, when you are working men overtime and striving earnestly to increase output per hour, tools and dies can defeat your efforts by causing too many machine stoppages for tool regrinding, repairing and replacements.

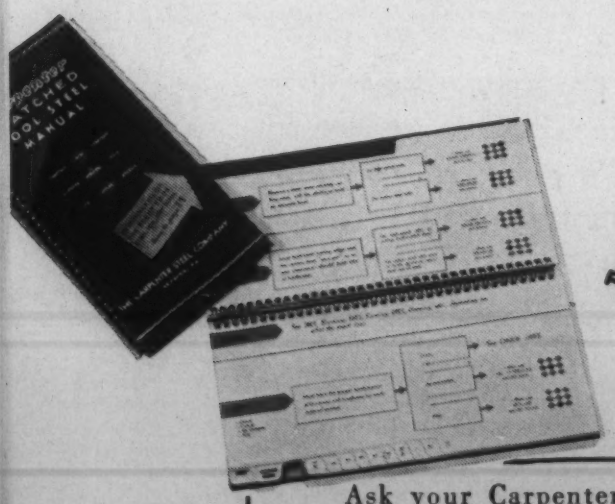
That's where users of Carpenter *Matched* Tool Steels have a definite advantage. They get more and faster output because their tools *work more hours with fewer interruptions.*

HERE'S WHY!

. . . 1. *Acid Disc Inspection* of Tool Steels, introduced by Carpenter in 1929, allows only clean, sound stock to reach customers.

. . . 2. *Tough Timbre Control,* introduced by Carpenter in 1930, provides those tool steels with a wide margin of safety in hardening.

. . . 3. *The Matched Set Method,* introduced by Carpenter

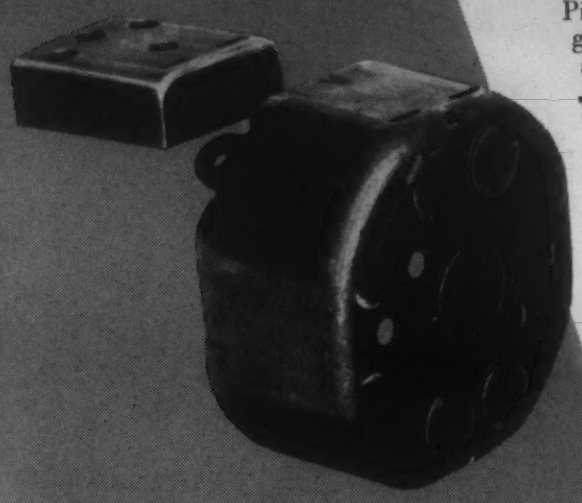


Ask your Carpenter representative for a copy of this manual. It contains detailed working instructions and the new 81-page alphabetical *Tool Index and Steel Selector.*

The Standard Tool Steels of Industry

Carpenter

BRANCH WAREHOUSES AT—Chicago, Cleveland, Detroit, Hartford, St. Louis, Indianapolis, Philadelphia,

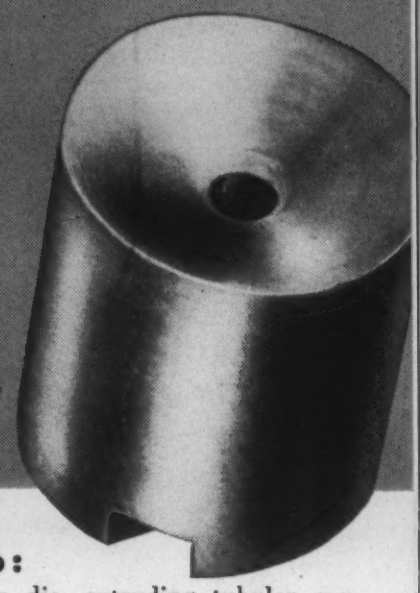


The Job:
Piercing die used in piercing slots in 14 gauge hot rolled steel at a production speed of 1,200 pieces per hour.

The Problem:
Breakage occurred on narrow side of die after about 2,500 pieces. Heat treatment and hardness tests showed okay.

The Matched Set Solution:
Recognizing the need for a tougher oil-hardening steel to withstand piercing impacts, the Superintendent, guided by the MATCHED SET method, selected Carpenter *R.D.S.* RESULTS: 1. Breakage overcome. 2. Tool life increased from 2,500 to 1,000,000 pieces. 3. Production per month increased by 39,400 pieces through eliminating 33 hours of tool-caused idle press time.

SOLVING TOOL PROBLEMS THE *Matched Set* WAY



The Job:
Extrusion die, extruding tubular gunpowder in a 30-opening extrusion press.

The Problem:
Abrasion grooved the dies in five days of operation. Time required for tool room repolishing was one-half hour for each of the 30 dies in the press.

The Matched Set Solution:
It was evident that more wear resistance was required. At the same time, the die must hold size accurately in hardening. *Hampden* was indicated by the MATCHED SET method. RESULTS: 1. An increase of 37 days in the production time between polishings. 2. A saving of 66 hours per month in tool room polishing time. 3. 132 fewer tools to remake or repolish per month.

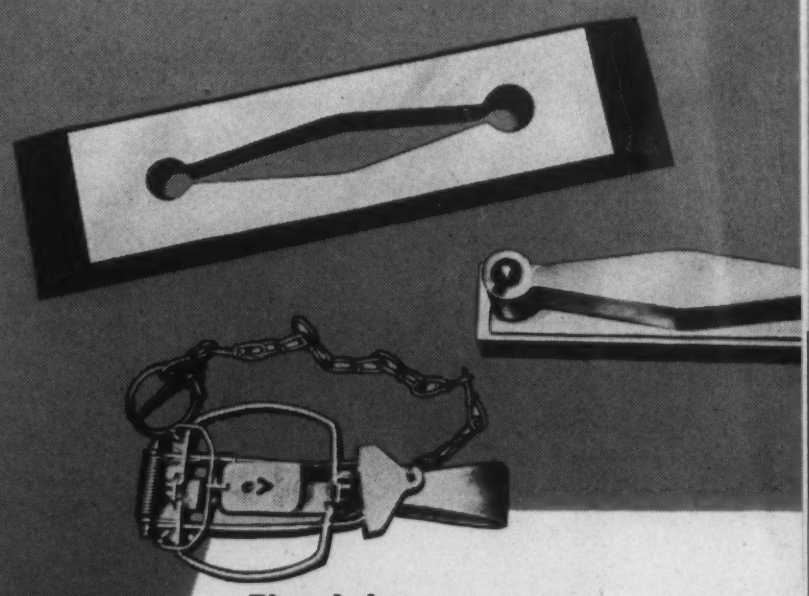
CLOCK, TOO!

in 1935, simplifies the problem of selecting the right steel for the job.

. . . 4. *Correct Heat Treating Data*, available in printed form for all Carpenter Tool Steels, insures maximum performance.

Helping customers get more out of their tool room set-up and their production equipment is one way that Carpenter is striving to meet the urgent needs of the defense program. For this purpose we have prepared a new, handy MATCHED TOOL STEEL MANUAL. This new Carpenter manual is complete . . . from a chart of the nine MATCHED TOOL STEELS showing how to solve problems the MATCHED SET way . . . to detailed heat treating and drawing instructions. Added to this manual is an 81-page alphabetical *Tool Index and Steel Selector*. It quickly shows which steel best meets the requirements of each job. If you do not already have a copy of this helpful 168-page MANUAL, ask your Carpenter representative. He has one for you.

THE CARPENTER STEEL COMPANY
READING, PA.



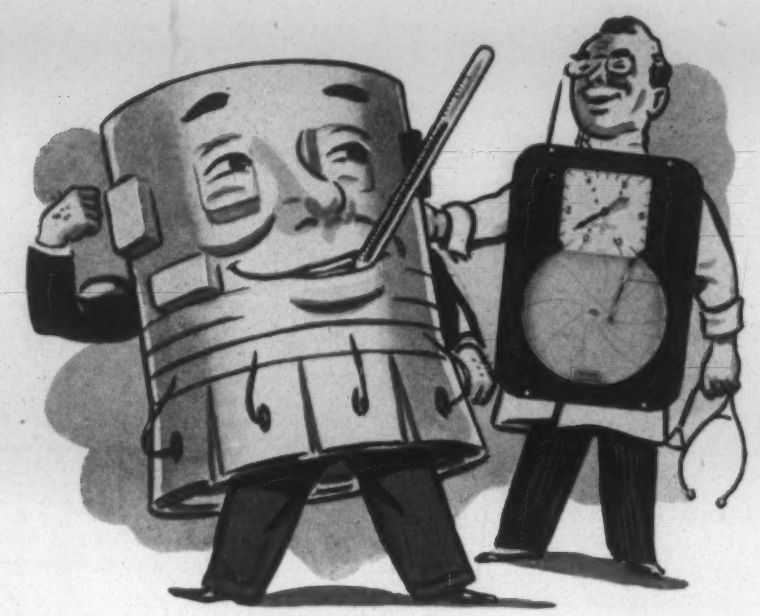
The Job:
Cutting springs from 55-60 carbon steel for making animal traps on a high production basis.

The Problem:
Trouble with burrs, too many press shutdowns for regrinding and short tool life.

The Matched Set Solution:
The tool room Foreman, using the MATCHED SET method, selected Carpenter *Hampden*, a long-wearing non-deforming die steel. RESULT: 1. A saving on shutdown time per press of 2.26 hours per month. 2. An increase in life per grind from 100,000 to 150,000 pieces. 3. Total life of the tool increased from 1,400,000 to 2,500,000 pieces. 4. Freedom from burrs.

MATCHED TOOL STEELS

PYROMASTER HOLDS ANNEALING TEMPERATURE CONSTANT FOR HIGHER OUTPUT



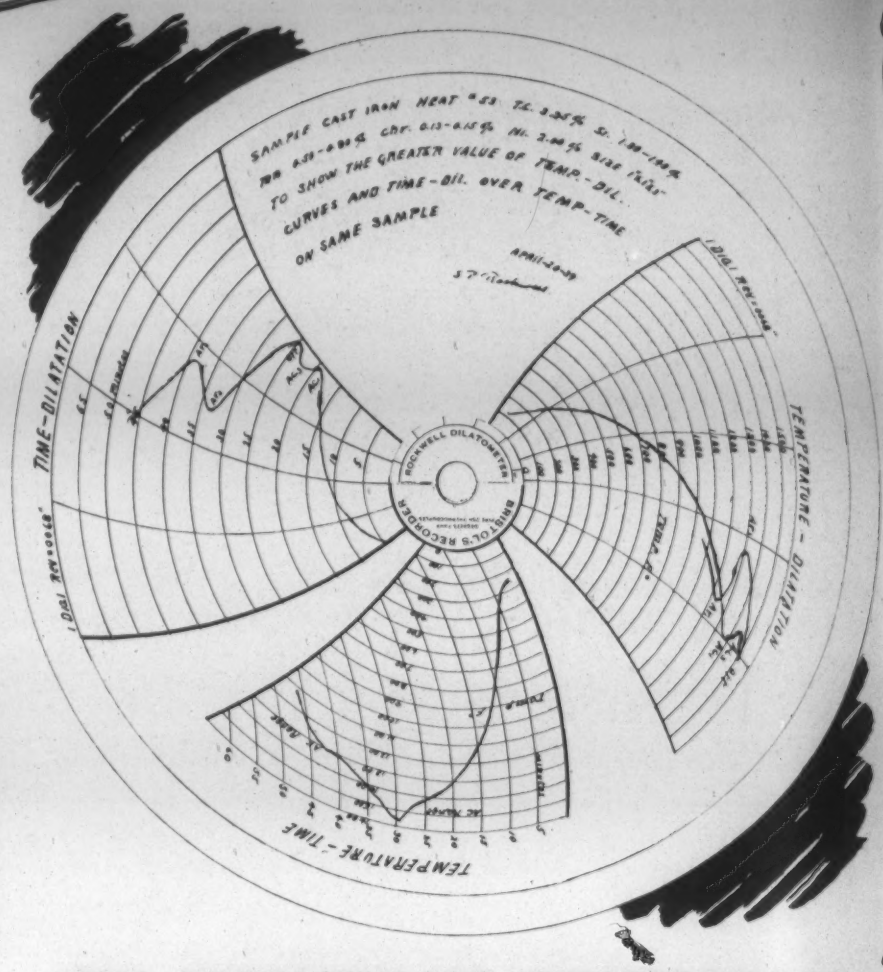
To maintain most efficient temperature for bright annealing stainless steel sheets, a large steel manufacturer in the Pittsburgh area uses Bristol Pyromasters and Wide-Strip Recorder Controllers.

On two electric bell-type furnaces, separate Pyromasters control temperatures as desired at different points in the furnaces. Two gas-fired furnaces of the same type and two rectangular type employ Wide-Strip Recorder Controllers which operate from the heating tubes until desired temperature is reached, then switch over to Pyromasters which control from Thermocouples in the work.

This ensures a constant maximum temperature for highest efficiency, with minimum let-down or interruption.

BRISTOL'S

Complete information on request.



TIME, DILATATION AND TEMPERATURE ON ONE CHART... THE MODERN METHOD

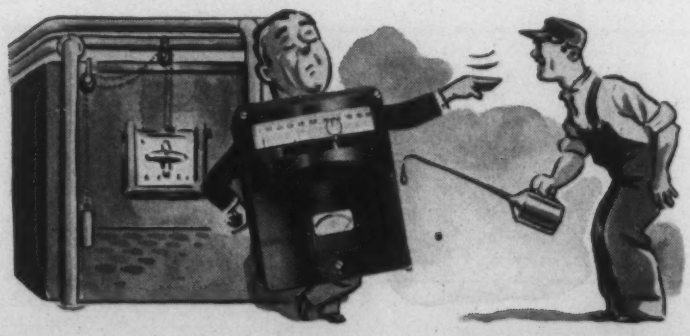
The ROCKWELL-BRISTOL DILATOMETER — for steel and other materials plots dilatation against both time and temperature on *one* conventional chart, (without photographing) — rather than the usual time-temperature method of depicting transformations or criticals — the point where under intense heat they contract for a while after first expanding.

This 100% American-made Dilatometer is acknowledged superior to foreign makes now impossible to obtain. The sharp, clear dilatometric reversals give exact understanding of the metal. And it is *simpler to operate* — needs no expert to run it. Practical for plant laboratory use.

BRISTOL'S

For Full Information Send for Bulletin No. 546.

BRISTOL'S ELECTRONIC PYROMETER . . .



FOR TROUBLE-FREE TEMPERATURE CONTROL

Used for automatic control of oven and furnace temperatures up to 3600° F., this Electronic Pyrometer combines a standard Millivoltmeter Pyrometer equipped with cold-end compensator and a control circuit operating on a relay regulating fuel supply. *No mechanical or electrical connection between the units* — measuring element is freed from mechanical work, assuring accurate, sensitive response to fluctuation. Control unit has no moving parts to wear or require maintenance — *no oiling* required. For all types of furnaces — whether fuel is gas, electricity or oil; also stoker-fed.

Complete data available in free Bulletin 554.
Write 114 Bristol Road, Waterbury, Conn.

BRISTOL'S

... Gives YOU the Most from Heat

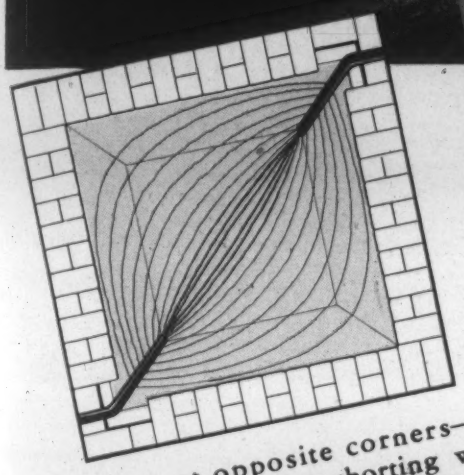
THE BRISTOL COMPANY
WATERBURY, CONNECTICUT

THE BRISTOL CO. OF CANADA, LTD.
Toronto, Ontario

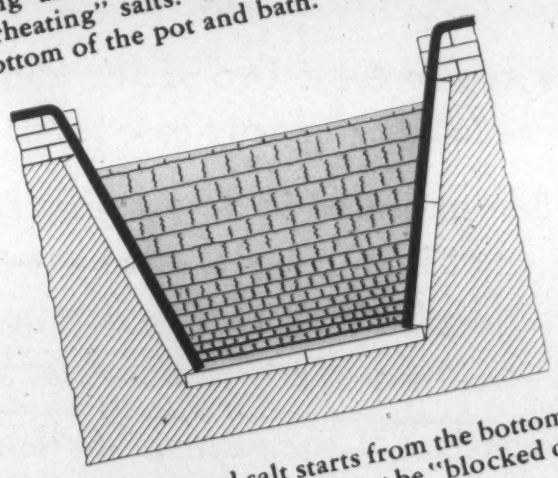
BRISTOL'S INSTRUMENT CO., LTD.
London, N.W. 10, England

AUTOMATIC CONTROLLING AND RECORDING INSTRUMENTS

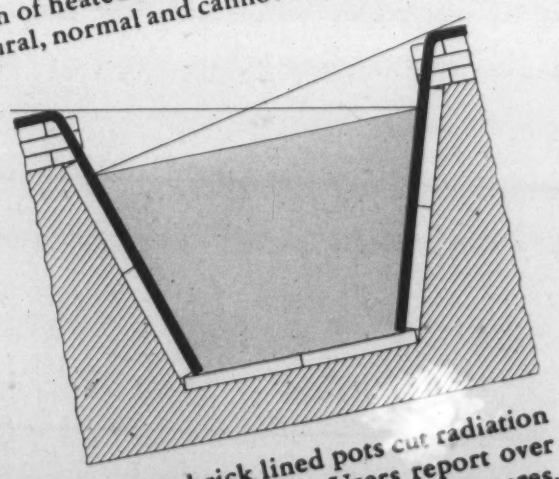
Scale-Free Heat Treating with ELECTROTHERMIC-PERMEATION



Electrodes at opposite corners—out of working area—prevent shorting work or "superheating" salts. Current spreads over the bottom of the pot and bath.



Full circulation of heated salt starts from the bottom of the pot, is natural, normal and cannot be "blocked off".



Extra high wall and ceramic brick lined pots cut radiation losses—improve working conditions. Users report over 8,000 hours continuous operation at all temperatures.

Only in the Upton Electric Salt Bath Furnace do you get this improved method of internal heating. Current generates heat everywhere throughout the entire bath.

Faster operation, more uniform work and savings in operation costs of upwards of $1200 per year are because of the greater efficiencies of Electrothermic-Permeation and other advanced Upton design features.

Every Upton furnace employs the Electrothermic-Permeation method. And Upton Electric Salt Bath Furnaces are available for virtually any heat treating work requiring from 300 to 2500° F.

Ask us what results other manufacturers in your field are getting on work similar to yours with the Upton Electric Salt Bath Furnace.

No matter what you Heat Treat . . . our engineers will prove invaluable in assisting you. No obligation.

Send me your NEW catalog.

NAME_____

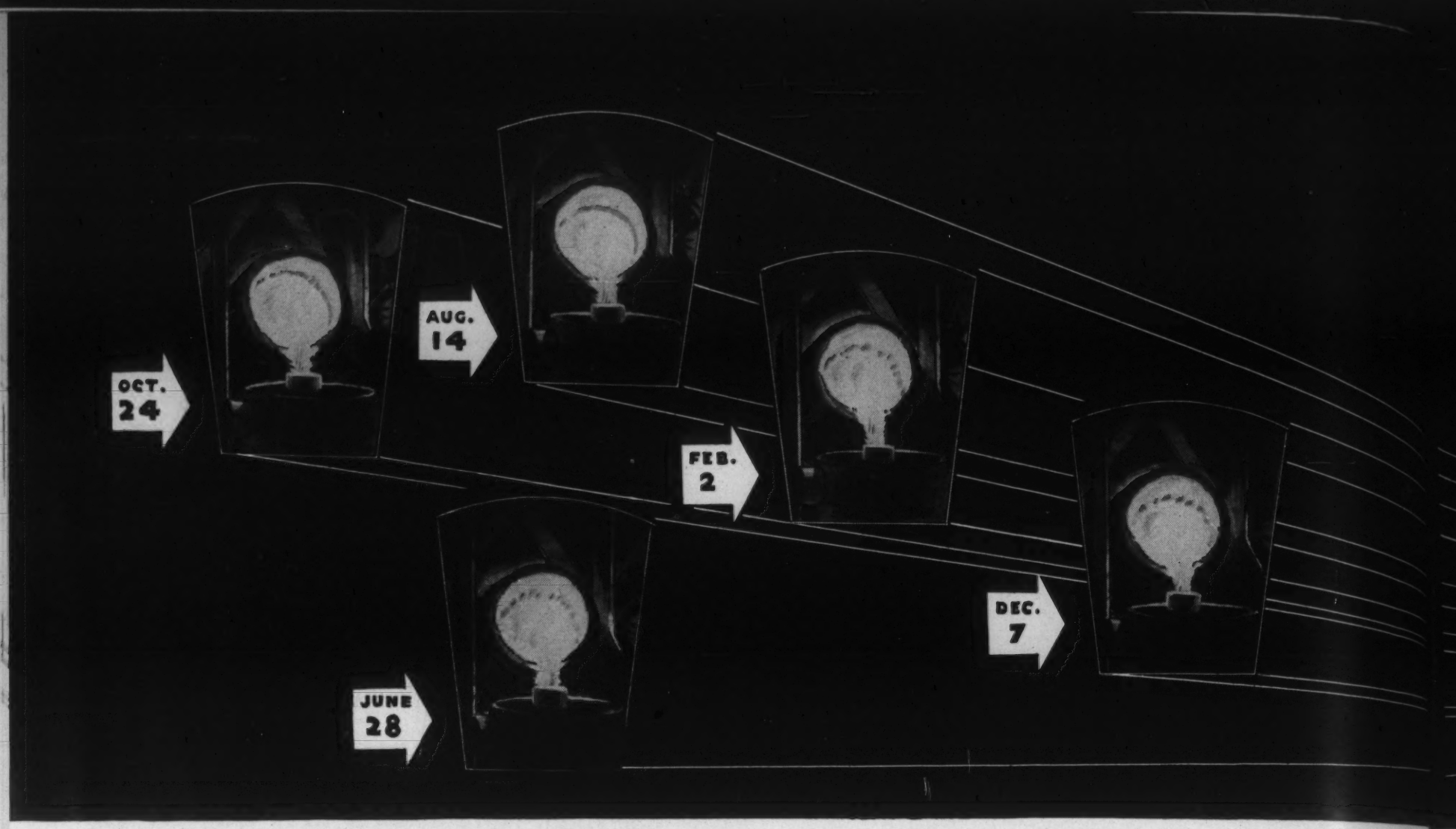
TITLE_____

COMPANY_____

ADDRESS_____

UPTON ELECTRIC FURNACE DIV.

7456 Melville at Green Commerce Pattern Foundry & Machine Co. **Detroit**



MONTH AFTER MONTH WITHIN 1/32"—

V-Foundry Alloys were developed several years ago to treat two of the knottiest problems of the foundry industry — control and reproducibility in gray cast iron.

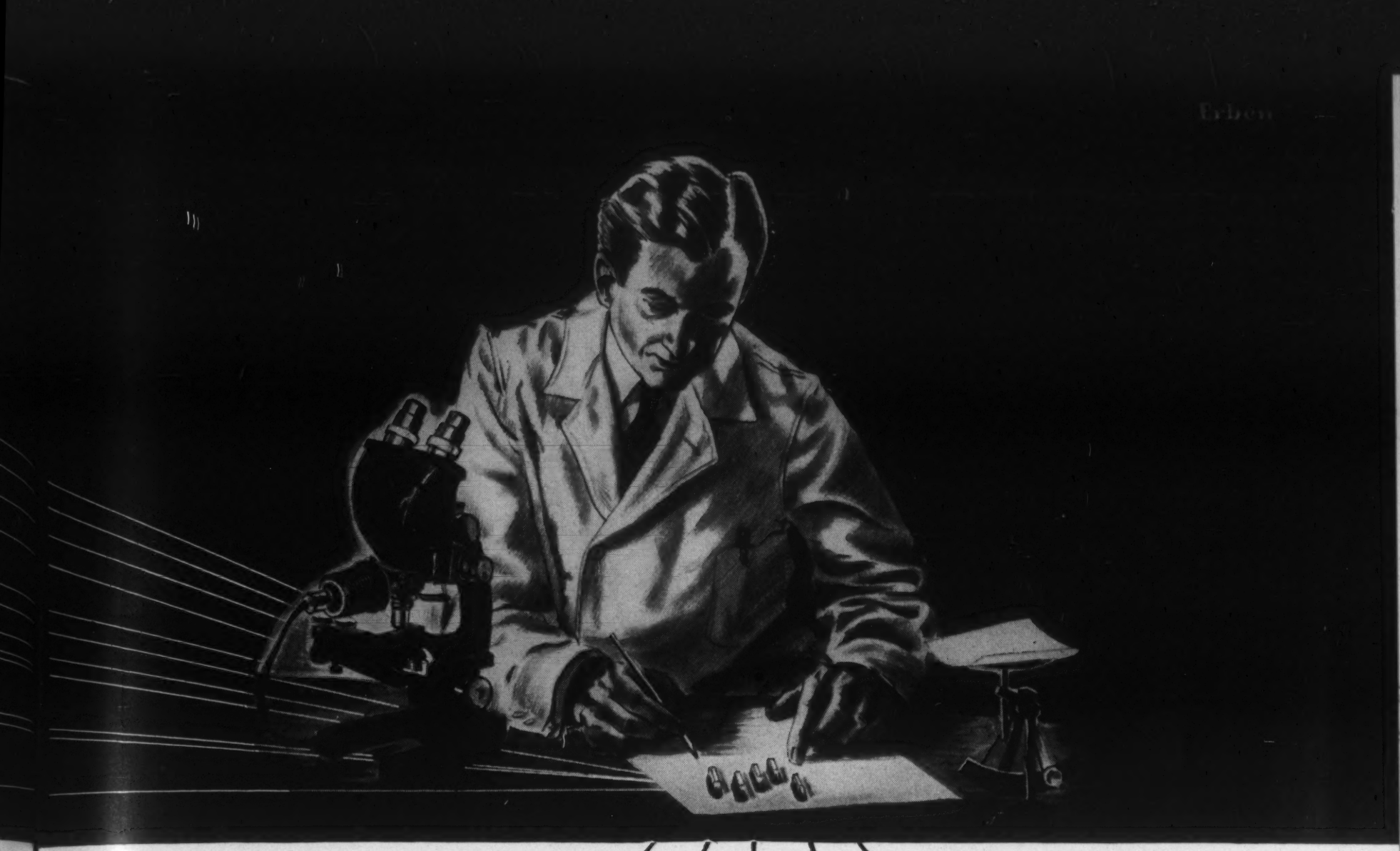
How well V-Alloys serve this purpose is being demonstrated in an ever-increasing number of foundries. The reports show, for example, that in V-Alloy-treated gray iron castings of the same composition, the variation in chill depth from cast to cast is only 1/32" to 2/32".

Reproducibility is apparently just as reliable at one time of the year as another. In all conditions of weather and moisture, in spite of variations in coke, pig iron, and scrap, if composition is the same, report after report shows no change in the narrow range of physical properties.

Tensile strength of most irons is slightly improved by V-Alloys. More important, the variation is always much less than in untreated irons and specifications are more easily met.

Brinell hardness is commonly controllable within 20-25 points. Due to the greater uniformity of hardness and elimination of hard spots, machinability is at least as good or, in many cases, is improved despite the increase in tensile strength.

VANADIUM CORPORATION OF AMERICA · NEW YORK, N.Y.



Although tensile strength is only a part of the story, many manufacturers have found V-Alloy practice extremely efficient for taking irons from the "30" classification to the "40" classification, achieving a remarkable improvement in machinability, and getting the result at a very small increase in cost.

A further advantage is that the effect of any reasonable excess of V-Alloy is solely beneficial. After the minimum necessary for reaction purposes has brought the iron to the proper state of equilibrium, excess additions over a considerable range do not disturb this balance, but effect a true alloy-improvement in physical properties.

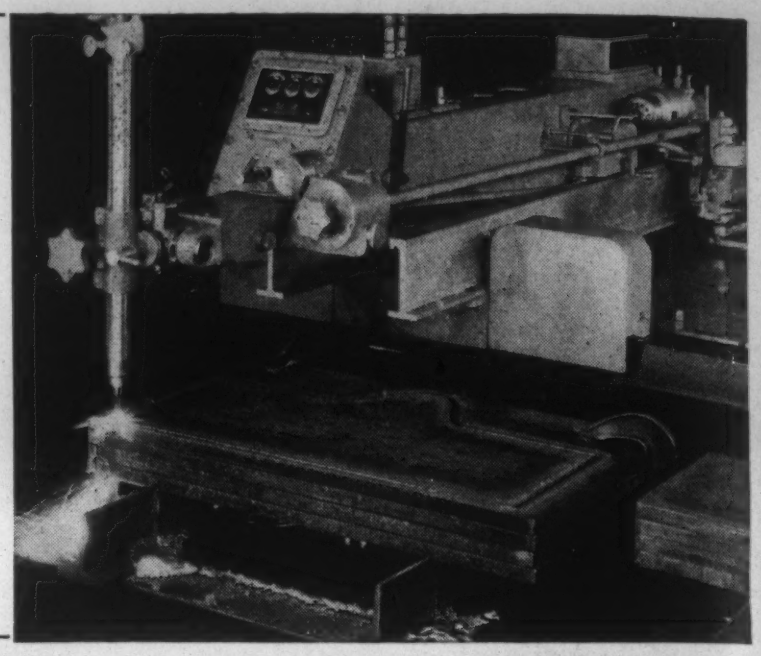
Two alloys — V-5 and V-7 — are available, the best one to use depending on the particular situation. Upon request, our metallurgical staff, fully acquainted with this entire development, will be glad to assist in selection and any applications of these alloys.

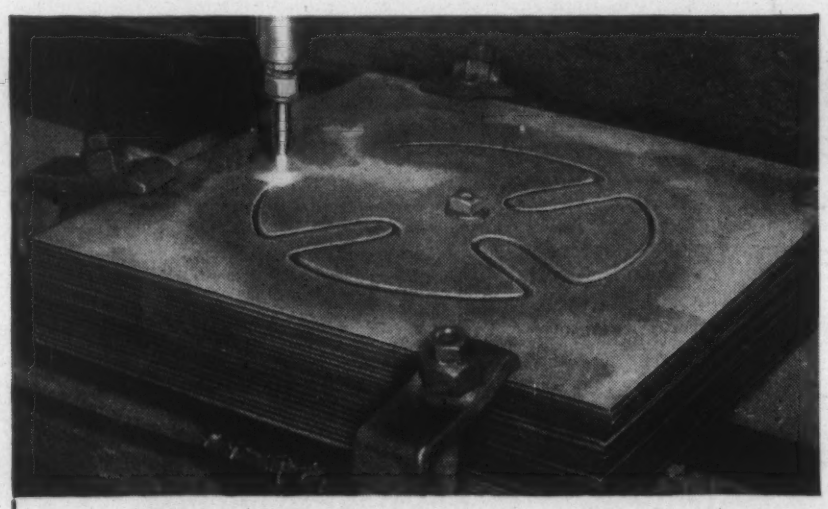
FERRO-ALLOYS

OXY-ACETYLENE STACK-CUTTING Quickly Produces Identical Parts from Stock Steel

1. What it is

Oxy-acetylene stack-cutting is an adaptation of the flame-shaping process. This method produces quantities of identically shaped parts of practically any size from clamped piles of steel plates or sheets. Steel ranging in thickness from 16 gauge to 1 inch is being cut with good results—in piles as thick as 5 inches. If the plates are correctly clamped, the cut edges are clean and smooth. Stack-cutting can be done with either portable or stationary flame-cutting machines. In the illustration at the right, an Oxweld cutting blowpipe is slicing through 4 plates, each 1 inch thick.





2. How it saves

Oxy-acetylene stack-cutting produces needed parts from stock steel quickly, and usually at lower cost than parts already shaped can be obtained. Stack-cutting is in most cases a faster and cheaper method than shaping single parts by mechanical means, and it also helps conserve steel because it reduces scrap losses. Additional savings result when machining operations are done on the flame-cut stacks before the parts are separated. The uniformity of stack-cut parts facilitates fabrication and assembly.

3. Linde can help you use it

Linde can help you determine where and how you can profitably use Oxweld flame-cutting equipment for the shaping of parts by stack-cutting. In addition to supplying the oxygen, the acetylene, and other essential materials, Linde also makes available to its customers, motion picture showings, how-to-do-it literature, and on-the-job service which help operators do a consistently good stack-cutting job. If you want to know more about this process—or about any other oxy-acetylene process—*ask Linde!*

THE LINDE AIR PRODUCTS COMPANY

Unit of Union Carbide and Carbon Corporation

30 E. 42nd St., New York, N. Y. UCC **Offices in Other Principal Cities**

In Canada: Dominion Oxygen Company, Limited, Toronto

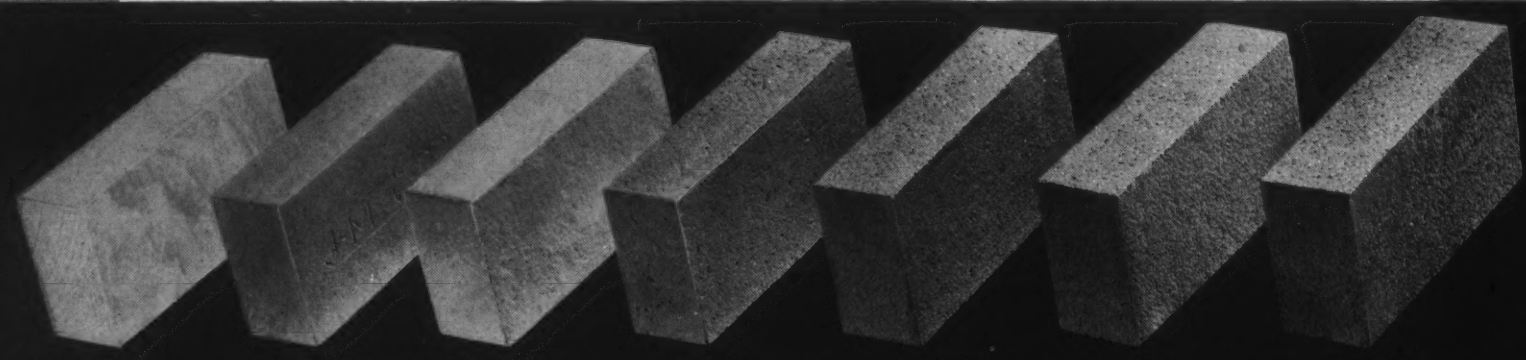
LINDE OXYGEN . . . PREST-O-LITE ACETYLENE . . . UNION CARBIDE
OXWELD, PUROX, PREST-O-WELD APPARATUS . . . OXWELD SUPPLIES

The words "Linde," "Prest-O-Lite," "Union," "Oxweld," "Purox." and "Prest-O-Weld" are trade-marks of Units of Union Carbide and Carbon Corporation.

Seasons
Greetings
SALEM
ENGINEERING
COMPANY

DO YOU HAVE THE FACTS ON THIS COMPLETE LINE

of J-M Insulating Brick and Insulating Fire Brick?



SIL-O-CEL NATURAL INSULATING BRICK	SIL-O-CEL C-22 INSULATING BRICK	SIL-O-CEL SUPER INSULATING BRICK	JM-16 INSULATING FIRE BRICK	JM-20 INSULATING FIRE BRICK	JM-23 INSULATING FIRE BRICK	JM-26 INSULATING FIRE BRICK
Back Up—1600° F.	Back Up—2000° F.	Back Up—2500° F.	Back Up—2000° F. Exposed—1600° F.	Back Up—2000° F. Exposed—2000° F.	Back Up—2300° F. Exposed—2300° F.	Back Up—2600° F. Exposed—2600° F.

NOW, with the recent addition of three *new* brick, the J-M Line includes seven insulating brick and insulating fire brick—each designed for a specific temperature and service. Like all J-M Insulating Materials, they can be relied upon for dependable performance under severe operating conditions.

For a complete description of the properties and characteristics of these seven Johns-Manville Brick, ask for folder IN-91A. Johns-Manville, 22 E. 40th Street, New York, N. Y.

Service Recommendations for J-M Brick

Here is a partial list of the many types of furnaces and equipment where the seven Johns-Manville Brick shown on this page are recommended for use as insulating fire brick or as insulating brick behind a refractory lining:

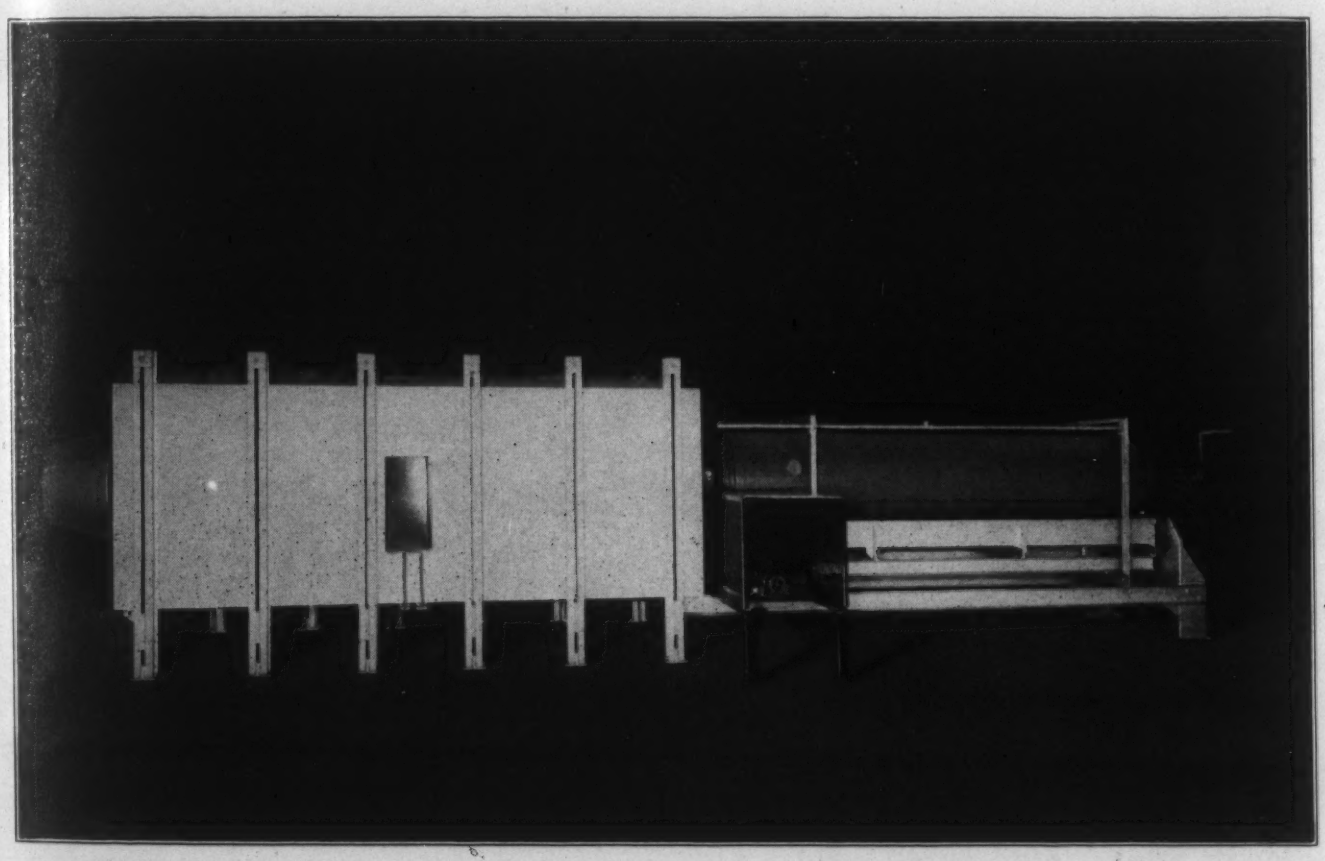
Annealing Furnaces
Bake Ovens
Bustle Pipes
Carburizing Furnaces
Case Hardening Furnaces
Drawing Furnaces
Electric Furnaces
Flues
Forge Furnaces
Gas Producers
Galvanizing and Tinning Furnaces
Hardening Furnaces
Hot Blast Mains
Hot Blast Stoves
Heat Treating Furnaces
Incinerators
Japanning Ovens
Normalizing Furnaces
Open Hearth Furnaces
Oil Heaters and Stills
Producer Gas Mains
Recuperators
Regenerators
Retorts
Radiant Tube Annealing Covers
Soaking Pits
Stress Relieving Furnaces
Stacks
Salt Bath Furnaces

All J-M Insulating Brick and Insulating Fire Brick furnished accurately sized in standard 9" shapes of the 2½" and 3" series, and in special sizes.

Johns-Manville
INDUSTRIAL INSULATIONS
For every temperature . . . for every service

90 MILLION CARTRIDGE SHELLS PER DAY

45 of these furnaces are in daily operation and 45 furnaces are in process of manufacture by the **AMERICAN ELECTRIC FURNACE COMPANY.** Work is automatically fed through the heating retort and cooling drum. Work is **Clean Annealed.**



Retort 16″ diam. x 9′ long. Cooling Drum 26″ diam. x 9½′ long. 106 K.W. with 2 zone temperature control.

Buy "AMERICAN"

Write for prices.

American Electric Furnace Company

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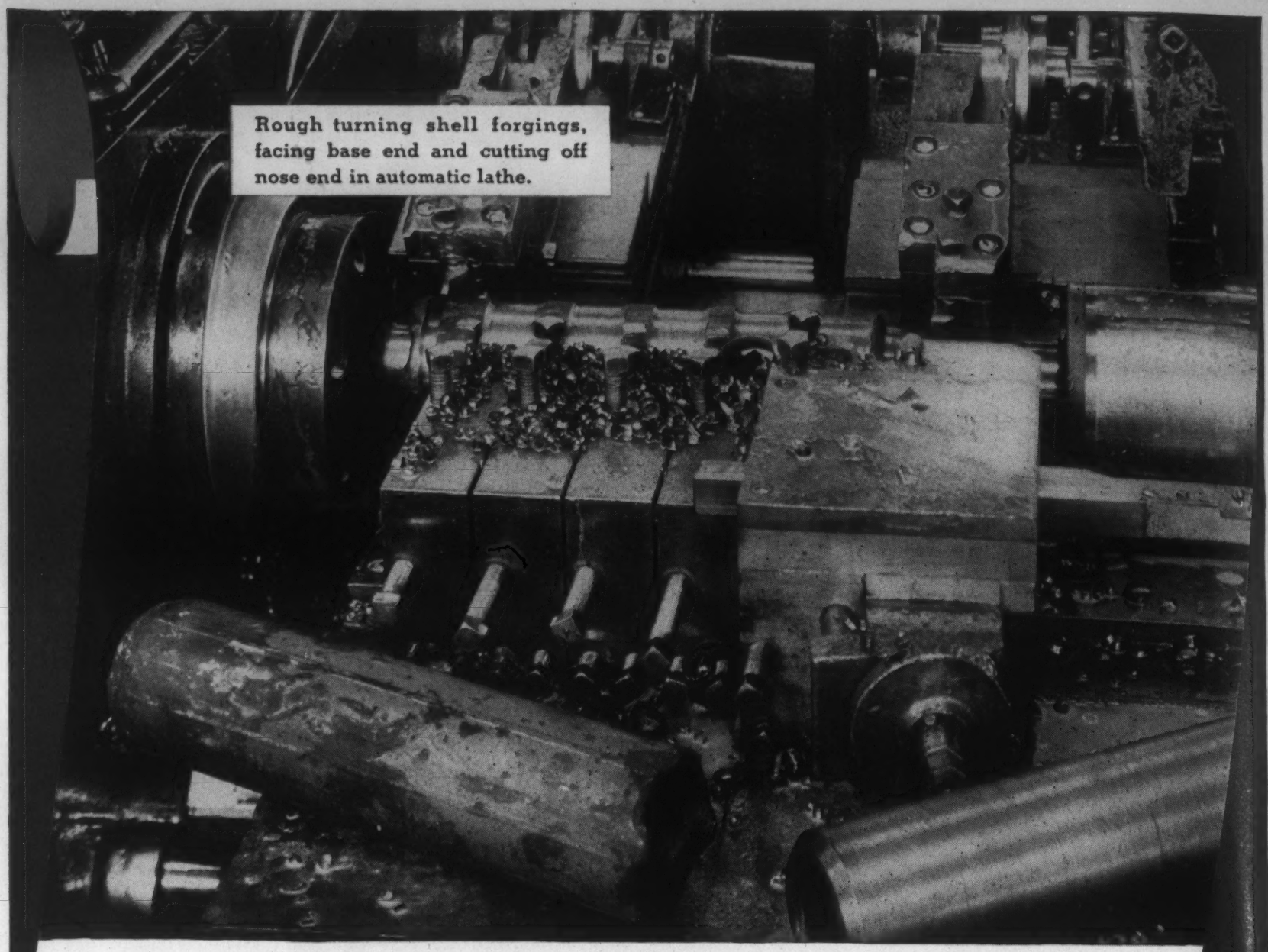

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Alloyed Irons for Temperature Resistance. Sterling Alloys, Inc. (1-150)

Alloy Steels

High Strength Steel. Alan Wood Steel Co. (1-1)

Low Alloy Steel. Bethelehem Steel Co. (1-117)

Molybdenum Iron and Steel. Climax Molybdenum Co. (1-76)

Gov't. Specifications for Alloy Steels. Peter A. Frasse & Co. (1-121)

High Strength Steel. Great Lakes Steel Co. (1-2)

High Strength Steel. Inland Steel Co. (1-90)

Molybdenum Steels and Irons. Molybdenum Corp. of America. (1-133)

Fatigue of Metals. Nitralloy Corporation. (1-147)

Hard Facing Alloys. Wall-Colmonoy Corp. (1-151)

Carbon Steels

Free-Machining Carburizing Steel. W. J. Holliday & Co. (1-103)

General Steel Products. Standard Steel Works Div., Baldwin Locomotive Works. (1-113)

High Speed Steels

High Speed Tool Steels. Vanadium Alloys Steel Co. (1-152)

Mo-Max High Speed Steels. Cleveland Twist Drill Co. (1-11)

Stainless Steels

Nitrogen in Chromium Alloy Steels. Electro Metallurgical Co. A comprehensive discussion of the effects of nitrogen in chromium alloy steels, based on the results of a large number of tests. (1-155)

Stainless Clad Steel. Ingersoll Steel & Disc Div., Borg Warner Corp. (1-104)

Stainless and Heat Resisting Steels. Republic Steel Corp. (1-79)

Tool and Die Steels

Carbon Tool Steel. Jessop Steel Co. Straight carbon tool steels, their advantages and applications, instructions on hot working and heat treatment, tips on tool design, are all concisely presented in 8 pages. (1-156)

Stainless and Tool Steels. Allegheny Ludlum Steel Corp. (1-134)

Die Steels. Latrobe Electric Steel Co. (1-149)

Graphitic Steels. Timken Steel & Tube Div., Timken Roller Bearing Co. (1-142)

Irons and Steels—General

Clad Steel Plate. International Nickel Co., Inc. A well presented, practical publication on the methods of fabrication of clad steel plate—12 pages, illustrations, tables and diagrams. Includes properties, design and welding of nickel-clad steels. (1-154)

SAE and AISI Specification Comparison. Jos. T. Ryerson & Son, Inc. Timely and helpful, this 23-page booklet gives direct comparisons of these two steel identification systems in tabular form. Both systems are explained and complete analyses ranges for carbon and alloy steels are listed. (1-153)

Iron Powders. Advance Solvents & Chemical Corp. (1-148)

Specialty Steel Stock List. Crucible Steel Co. of America. (1-110)

2. Non-Ferrous Metals

Copper and its Alloys

Bearings, Bushings and Castings of Bronze. Ampco Metal, Inc. Two new bulletins describing the applications of copper alloys in bearings, bushings and castings. Both folders are 6 pages in length and attractively present case histories to point out the advantages of bronze in these applications. (2-150)

Copper Alloys. American Brass Co. (2-106)

Phosphor Bronze. Phosphor Bronze Smelting Co. (2-100)

Copper, Brass and Bronze Weights and Data. Revere Copper & Brass, Inc. (2-82)

Oxygen-Free Copper. Scomet Engineering Co. (2-145)

Special Copper Alloys. Seymour Mfg. Co. (2-101)

Brass and Bronze. Titan Metal Mfg. Co. (2-102)

Light Metals

Magnesium Alloys. Dow Chemical Co. (2-104)

Precious Metals

Silver as a Raw Material. Silver Producers Research Project. A 12-page reprint of an article describing the important industrial uses of silver and its alloys. The paper is well-written and instructive. (2-152)

Special Metals

Nickel Alloys for Heat Resisting and Electrical Uses. Driver-Harris Co. Some interesting applications for special nickel alloys are described and illustrated in a 4-page folder. (2-151)

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Alloy Powders. Ekstrand & Tholand, Inc. (2-93)

Rare Metals, Alloys and Ores. Foote Mineral Co. (2-19)

Bibliography on Indium. Indium Corporation of America. (2-91)

Lithium and its Alloys. Lithaloys Corporation. (2-116)

Metallic Hydrides. Metal Hydrides, Inc (2-144)

Metal Powders. Powder Metals & Alloys, Inc. (2-149)

3. Engineering Design

Alloy Castings

Heat Resisting Alloy. Chicago Steel Foundry Co. (3-19)

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Ductile Iron Castings. Ferrous Metals Corp. (3-57)

Silver Stainless Steel Castings. Lebanon Steel Foundry Co. (3-90)

Design for Strong Castings. Meehanite Research Inst. of America. (3-102)

Corrosion and Heat Resistant Castings. Michiana Products Corp. (3-91)

Aluminum Castings for Stair Treads. National Bronze & Aluminum Foundry Co. (3-127)

Aluminum Die Casting. Madison-Kipp Corp. (3-151)

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Wear Resistant Precious Metal Parts. Permo Products Co. (3-65)

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Bi-metals and Electric Contacts. H. A. Wilson Co. (3-70)

Metal Parts

Bi-Metals. General Plate Div., Metals & Controls Corp. **(3-155)**

Non-Metallics

Plastics Review. Bakelite Corp. An interesting booklet, published quarterly by the Bakelite Corp., is designed to inform manufacturers, designers, engineers and chemists of the latest developments in their plastics. Runs about 20 pages. (3-153)

Non-Metallic Materials. Continental Diamond Fibre Co. (3-129)

Cellulose Acetate Plastics. Hercules Powder Co. (3-108)

Plastics in the Emergency. Monsanto Chemical Co., Plastics Div. (3-96)

New Corrosion Resistant Material. U. S. Stoneware Co. (3-95)

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Electrolytic and Sponge Iron Powder. Plastic Metals, Inc. (3-152)

Powder Metallurgy Products. Powder Metallurgy Inc. (3-89)

Tubing

Carbon or Alloy Steel Tubing. Ohio Seamless Tube Co. Tubing, how it is made, what its uses and applications are, and its advantages, are outlined, described and illustrated in this 8-page pamphlet. (3-154)

Tubes and Pipes. Babcock & Wilcox Co. (3-143)

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New Steel Making Alloys. Vanadium Corp. of America. (4-43)

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Magnetic Separators. Dings Magnetic Separator Co. (4-66)

Melting Furnaces and Parts

Melting Furnaces and Equipment. Mahr Manufacturing Co. A series of 4 one-page bulletins related to melting furnaces of the pot and crucible type, oil burning ladle heaters, and oil regulating valves. All bulletins are illustrated and discuss briefly the furnace equipment. (4-74)

High Frequency Furnaces. Ajax Electrothermic Corp. (4-60)

Cutting Crucible Costs. Crucible Manufacturers' Association. (4-36)

Rocking Electric Furnaces. Detroit Electric Furnace Co. (4-52)

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Control of Furnace Atmosphere. C. I. Hayes, Inc. (5-33)

Gas and Air Scrubbers. Peabody Engineering Co. (5-203)

Drying Air or Gases. Pittsburgh Lectrodryer Co. (5-65)

Auxiliaries

Heat Treating Auxiliaries. American Manganese Steel Div., Am. Brake Shoe & Fdry. Co. Heat treating containers, retorts and a variety of furnace fixtures are described and illustrated in this 16-page booklet. The story behind the manufacture of these products is also very well presented. (5-248)

Fuel Oil Gasifier. American Gasifier Co. (5-138)

In this Manufacturers' Literature INDEX, new bulletins are given complete reviews, and previously described older bulletins are merely listed in their proper places.

Carburizing Boxes. Pressed Steel Co. (5-245)

Butterfly Valves. R-S Products Corp. (5-183)

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Balanced Carburizing Baths. American Cyanamid & Chemical Co. (5-135)

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Centrifugal Compressors. B. F. Sturtevant & Co. (5-237)

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Pre-Mixing Burners. Kemp of Baltimore. The use of the pre-mixing principle for burners in heat treating applications are described and many installations illustrated. (5-257)

High Pressure Inspirators. North American Mfg. Co. Another informative 4-page folder with vital information on high pressure inspirators for natural gas. Specifications and prices are listed. (5-249)

Oil Burning Equipment. Chicago Flexible Shaft Co. (5-170)

Controlled Luminous Flame for Billet Heating Furnaces. Morgan Construction Co. (5-147)

Electrical Hardening and Heating

Induction Hardening. Ohio Crankshaft Co. In 14 pages the induction hardening process is discussed and its advantages and applications pointed out. The booklet is well supplemented with photographs and graphs. (5-246)

Electric Forging Heaters. American Car & Foundry Co. (5-23)

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Furnaces and Furnace Equipment. Amsler-Morton Co. A large 24-page booklet illustrating equipment for almost every use in the heating and heat treating field. It is this company's 25th anniversary publication. (5-256)

Radiation-Type Heat Treating Furnaces. Bennett Insured Steel Treating Co. A heat treating furnace in which the heat is supplied by radiation, producing a non-oxidizing atmosphere for heat treating high speed tool steels and dies is described in this 4-page folder. (5-247)

Pit-Type Convection Furnace. Hevi Duty Electric Co. A 2-page leaflet gives briefly the application, operation and control of the pit-type convection furnace. A table of specifications is included. (5-252)

Direct Radiant Heat Gas Furnaces. Selas Company. Fourteen pages describe the direct radiant heating technique and discuss 18 varied furnace installations in the metals and metals-products field. (5-254)

Furnaces in the Aircraft Industry. Surface Combustion Corp. The role that these gas-fired furnaces are playing in heat treating departments of aircraft plants is related. Illustrations of some typical installations, with operating data, are given. (5-253)

Car Hearth Heat Treating Furnaces. Vulcan Corp. A 4-page folder briefly outlines their line of car hearth furnaces for normalizing, annealing or heat treating. (5-255)

Electric Pot Furnaces. American Electric Furnace Co. (5-97)

Furnaces, Burners, Etc. American Gas Furnace Co. (5-144)

Blowerless Furnaces. Baker & Co. (5-168)

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Ovens

Near Infra-Red Process. Fostoria Pressed Steel Corp. A 16-page presentation, with illustrations of various applications and equipment of this radiant energy process for baking, drying, preheating, etc. (5-251)

Foundry Ovens. Gehnrich Corp. A comprehensive, descriptive treatment of their line of foundry ovens for core baking and mold drying. Sixteen pages, profusely illustrated. (5-250)

Foundry Ovens. Despatch Oven Co. (5-187)

6. Refractories • Insulation

Refractory Coating Material. Brickseal Refractory Co. The problem of maintaining furnace walls is discussed, and a method of repair explained. A 4-page folder with illustrations of the repair procedure. (6-67)

Refractory Concrete. Atlas Lumnite Cement Co. (6-56)

Basic Refractories. Basic Refractories, Inc. (6-59)

Heavy Duty Refractories. Carborundum Co., Refractory Div. (6-45)

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Pocket Cost Calculator for Refractories and Insulation. Illinois Clay Products Co. (6-57)

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Electric Salt Bath Brazing. Ajax Electric Co., Inc. (7-63)

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Soldering, Brazing Flux. Special Chemicals Corp. (7-67)

Electric Arc Welding

Stainless Steel Welding. Arcos Corp. An instructive 11-page publication on the welding of stainless steel. Tables showing current values, weld metal characteristics, deposition data and heat treatment are featured. (7-103)

Arc Welding Check List. Hobart Brothers Co. A vest-pocket size pad with hints about 23 arc welding applications. Questions concerning them are interestingly presented and well illustrated in 40 pages. (7-102)

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Stainless Steel Welding Wire. Page Steel & Wire Div., Am. Chain & Cable Co. (7-93)

Flame-Processing

Progress in Flame Processing. Air Reduction Sales Co. A very attractive 54-page booklet, beautifully illustrated, presents an over-all picture of the products produced by Air Reduction, and the uses of these products. (7-100)

Oxyacetylene Welding and Cutting. Linde Air Products Co. (7-75)

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Low Temperature Welding. Eutectic Welding Alloys, Inc. A complete, comprehensive treatment of the subject of the low temperature welding process. 32 pages, it covers description of process, applications, and welding procedure for numerous metal forms and metals. (7-104).

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Resistance Welding Data Book. P. R. Mallory & Co. (7-87)

Seam Welders. Taylor-Winfield Corp. (7-99)

Spot Welding Timers. Westinghouse Electric & Mfg. Co. (7-77)

8. Metal-Working

Forming

Metal Spinning. Milwaukee Metal Spinning Co. Metal spinning is an intriguing method of metal forming. In this 4-page folder, a few of the highlights of the process are described. (8-101)

Grinding Facts. Norton Co. A question and answer booklet, 31 pages, especially intended for new operators of grinding machines. Instructive and clearly presented, with manifold expository illustrations. (8-105)

Forming Aluminum and its Alloys. Aluminum Co. of America. (8-88)

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Presses for Powdered Metals. Kux Machine Co. (8-62)

Powder Mixing Machines. National Engineering Co. (8-92)

Powder Metallurgy Presses, Molds. F. J. Stokes Machine Co. (8-54)

Machining

Sintered Carbide Cutting Tools. Firth-Sterling Steel Co. A user's handbook on sintered carbide cutting tools has just been issued, which tells how to make, use and maintain the tools. A new 12-page tool tip size and price list has also been published. (8-104)

Steel and Metal Cutting Tools and Blanks. McKenna Metals Co. An excellent booklet, 36 pages, gives the complete story of steel cutting carbide tools and blanks—examples of uses, grade selection and design, and tips on using carbide tools. (8-103)

Carbide Tools. Tungsten Carbide Tool Co. A 4-page bulletin covering the company's new line of cutting tools. Specifications and prices are given for steel-cutting, cast iron and non-ferrous cutting tool grades. (8-100)

Tantalum-Tungsten Carbide Tools and Blanks. Vascoloy-Ramet Corp. A useful, 27-page catalog lists typical single point tool styles, and gives a grade selector chart and tables for computing costs of standard tools, blanks and special blanks. (8-102)

Cemented Carbide Tools and Dies. Carboloy Co., Inc. (8-38)

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Cutting Oils. Cities Service Oil Co. (8-19)

Machining Zinc Die Castings. New Jersey Zinc Co. (8-69)

Cutting Oils and Industrial Lubricants. D A. Stuart Oil Co. (8-91)

9. Cleaning • Finishing

Cleaning

Airless Abrasive Blast Cleaning. American Foundry Equipment Co. Sixteen pages, an informative pamphlet on abrasive blasting using the centrifugal force principle. Explains the principle and mechanism involved, its advantages and applications. (9-121)

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Pickling Agent. Monsanto Chemical Co., Merrimac Div. (9-63)

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10. Testing • Control

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Automatic Control Instruments Index. Bristol Co. A condensed index of the Bristol products and the engineering service they offer. Includes all types of air operated and electrically-operated automatic control instruments. (10-204)

Proportioning Control System. Brown Instrument Co. The 22-page bulletin thoroughly describes a proportioning control system for furnace equipment. There are numerous diagrams and illustrations to augment the description. (10-209)

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Hardness Conversion Tables. Wilson Mechanical Instrument Co. (10-92)

Inspection Devices

Magnaflux Inspection. Magnaflux Corp. A new series of units for inspection of metal for defects by the Magnaflux principle are illustrated and described in a 4-page folder. (10-206)

Measuring Coating Thickness. American Instrument Co. (10-118)

Surface Smoothness Tester. Brush Development Co. (10-192)

Dial Indicators. Federal Products Corp. (10-125)

Carbon Meter. E. Leitz, Inc. (10-202)

Profilometer for Roughness Measurements. Physicists Research Co. (10-203)

New Illuminated Magnifier. E. W. Pike & Co. (10-58)

Mechanical Testing

Micro-Mechanical Study of Welds. R. Y. Ferner Co. A reprint of a paper presented at the symposium on welding iron and steel of the Iron & Steel Inst. in 1935—authoritative and educational, consisting of 20 pages. (10-207)

Torsion Impact Machine. Baldwin-Southwark Div. (10-99)

Fatigue Testing Machines. Krouse Testing Machine Co. (10-201)

Please Use the Coupon on Page 831

Strain Gages and Extensometers. Tinius Olsen Testing Machine Co. (10-161)

Universal Testing Machines. Riehle Testing Machine Div., Am. Machine & Metals Co. (10-144)

Tensile Testing of Fine Wire. Henry L. Scott Co. (10-55)

Metallographic Equipment

Photomicrographic Equipment. Bausch & Lomb Optical Co. (10-90)

Metallurgical Testing Apparatus. Adolph I. Buehler. (10-80)

Metallographic Polishing Machine. Cincinnati Electrical Tool Co. (10-193)

Metallurgical Polishing Equipment. Tracy C. Jarrett. (10-174)

Radiography

Gamma Ray Radiography. Canadian Radium & Uranium Corp. (10-172)

Modern Industrial Radiography. Eastman Kodak Co. (10-177)

The X-ray in Industry. General Electric X-ray Corp. (10-10)

Industrial X-ray. Kelley-Koett Mfg. Co. (10-185)

Radium for Radiography. Radium Chemical Co. (10-81)

X-ray Machines. Westinghouse X-ray Co. (10-164)

Spectrography

Analyzing Spectrographic Plates or Film. Leeds & Northrup Co. Twelve pages devoted to their equipment for spectrographic analysis. A clear exposition of the various parts of the microphotometer and their functions is given. (10-205)

Laboratory Aids

Salt Spray Test Containers. Alberene Stone Corp. of Virginia. (10-120)

Film and Plate Processing. Harry W. Dietert Co. (10-189)

Laboratory Equipment. Laboratory Equipment Co. (10-194)

11. General

Safety Equipment Catalog. American Optical Co. Complete protection from head to ankles is provided by the safety items described in this 111-page catalog. (11-32)

Dust Respirator. DeVilbiss Co. The features of the new respirator are discussed in a 4-page folder. A large, cut-away illustration shows the respirator's construction. (11-31)

Chemicals for All Industries. E. I. du-Pont de Nemours & Co., Inc. Many metallurgical engineers will have use for this 32-page quarterly price list of chemicals for all industries. (11-33)

Chilling Unit for Sub-Zero Temperatures. Kold-Hold Manufacturing Co. This unit, with many uses in the metal industries where sub-zero temperatures are required, is clearly described and illustrated in a 4-page folder. (11-34)

New Metal and Furnace Periodical. Ajax Metal Co. (11-29)

Dust Collectors. Pangborn Corp. (11-24)

Air Control. A. Schrader's Son Div., Scovill Mfg. Co. (11-30)

Vacuum Cleaning in Industry. Spencer Turbine Co. (11-28)

Magnetic Separators. Stearns Magnetic Mfg. Co. (11-25)

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CONTINUOUS ARMOR PLATE PRODUCTION

One of several Drever Roller Hearth Furnaces continuously producing armor plate in straight line production—hardening and tempering both face hardened and homogenous—without handling as required by conventional batch type furnaces. Oil or gas fired, these furnaces feature exceptional temperature uniformity in all zones with either fuel.

Further information on request.

THE DREVER COMPANY • 780 E. VENANGO ST. • PHILADELPHIA, PA.

XPERIENCE POINTS TO THE DREVER DESIGNERS & BUILDERS OF HEAT TREATING EQUIPMENT . . .

— and the answer is under his thumb !

Silver — the metal in the pencil — may be the best metal to meet the requirements. What other metal offers such industrially valuable qualities as SILVER?

It is one of the most ductile and workable metals known and combines readily with other metals to make useful alloys that have unusual properties. Silver is practically indestructible in its immunity to many kinds of corrosion and it is a superior conductor of electricity and heat. Silver is the whitest of metals and has high reflectivity. It also has excellent germicidal qualities and the salts of silver are photo-sensitive.

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Much vital data concerning Silver and its industrial uses is on record and readily available through the Service described at the left. If you have a specific metal problem, find out whether Silver can help to solve it. We invite you to write us.

SILVER DATA and RESEARCH . . .

The American Silver Producers' Research Project has for some years carried on a comprehensive research program covering silver and silver alloys for general and specific industrial uses. This research continues today under direction of Handy & Harman who specialize in supplying silver to the arts and industries.

A great deal of valuable data has been accumulated. These data are available to anyone interested in silver and its alloys for industrial application.

The full cooperation and research facilities of the Project are also offered for working out solutions to specific problems.

AMERICAN SILVER PRODUCER'S RESEARCH PROJECT

Under Direction of Handy & Harman

82 Fulton Street New York, N. Y.

If it's a metal problem, think of SILVER!

A SUBSTITUTE FOR COPPER

Silver laminated to unrestricted base metals in wire, flatstock or fabricated parts makes good conductive material-strong, dependable and capable of carrying current without loss or deterioration. So do low cost silver alloys—also available in all forms.

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Silver laminated metals—in flat stock, coils or tubing—are economical metals to use under corrosive conditions. The solid silver surface provides the protection from corrosion. And the base metal—permanently bonded to the silver—adds strength and rigidity.

IT'S ECONOMICAL TO USE

Due to General Plate's precision manufacturing processes, laminated silver metals are produced at a cost which makes them practical, when compared with solid precision metals, for almost all applications—regardless of size, shape, type or quantity required.

Silver Laminated Metals may Solve Your Substitute Problem

See if it is possible for you to make good use of the many types of laminated metals that General Plate engineers are producing for equipment manufacturers. For many years General Plate have specialized in developing laminated combinations of metals to meet unusual requirements economically. There is a possibility that General Plate can pull you out of your metal hole. If you have any requirements simply write, specifying them. Your request will be attended to promptly and confidentially.

General Plate Division *of Metals & Controls Corp.*

Metals and Controls Corporation Divisions manufacture the following products: Laminated & solid precious metals, electrical contacts—Solid and rolled plated precious metals in all forms Truflex Thermostatic Bimetals.

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For You . . .

GENTLEMEN

a priority on pulchritude

The new 1942 Varga Girl Calendar personalized with your company imprint — a generous gift for your patrons.

Esquire has produced another Varga Girl Calendar . . . a 1942, four-color, 12-page edition . . . 12 times better than the tremendously popular 1941 calendar.

And this year, for the first time, we're allowing personalization of the Varga Girl Calendar . . . allowing your company to have imprinted on the front of each calendar, or on each of the 12 pages, your company's name, address, and nature of business. In short, the 1942 Varga Girl Calendar is now available in quantities over 100, as your company's personalized gift to its patrons . . . a spectacular and beautiful ambassador of good will.

So, gentlemen, don't keep the Varga Girl waiting! She has a limited supply of paper stock and a block of dates a year in advance. But she's ready and willing to carry your best wishes to your best customers . . . for all of next year.

Just fill in, clip out, and order today! ➡

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COMPANY NAME _____

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.....copies of Esquire's 1942 Varga Girl Calendar without imprint .....@ 25c each

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☐ Send me the quantity of calendars indicated above.

☐ I shall send you a list from which to address and mail these calendars without extra cost.

$..... is enclosed as payment in full for the calendars.

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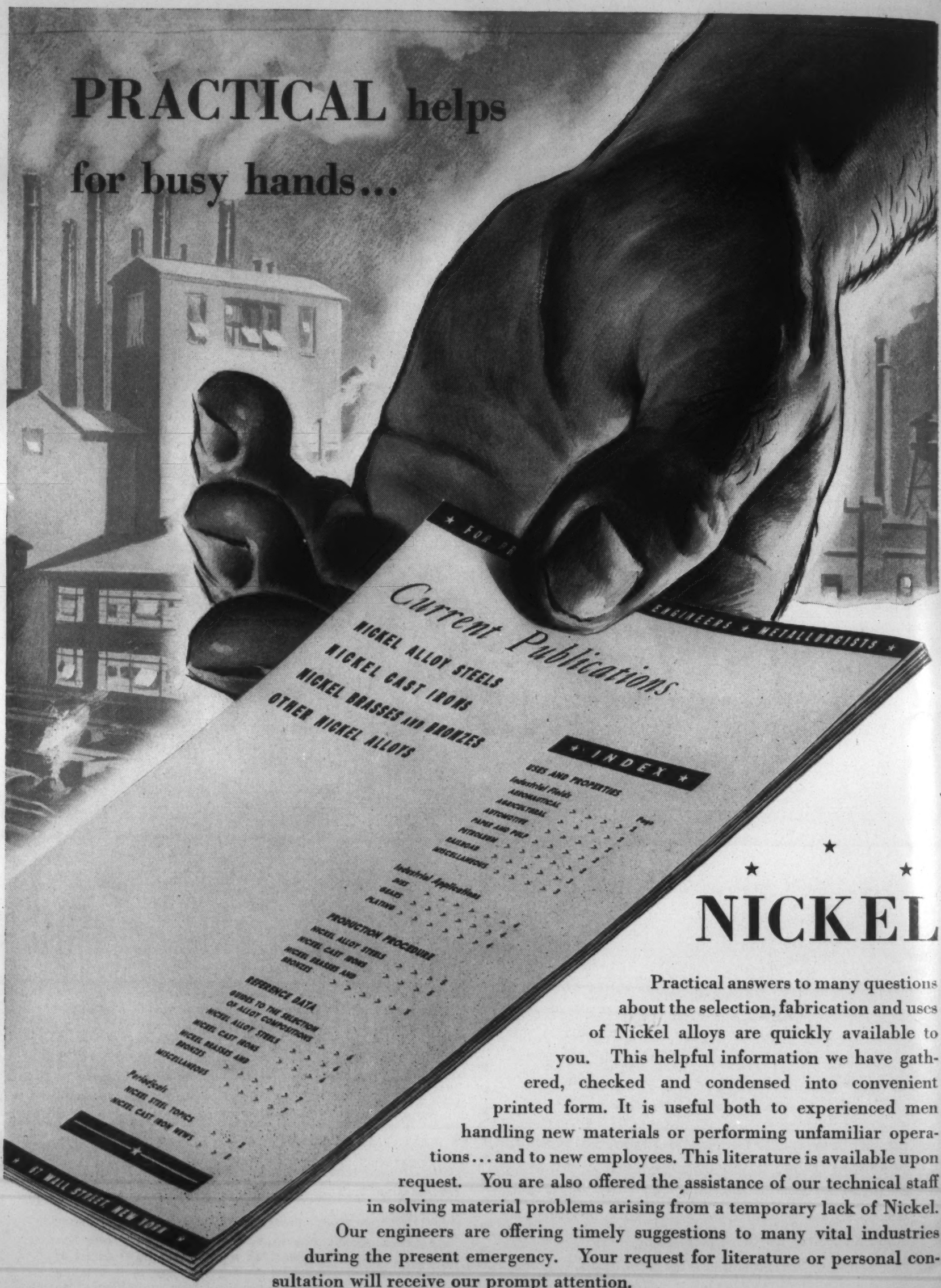
*The rates quoted above for imprinting apply only for quantities over 100 and include shipping to your address of each calendar in a separate mailing envelope, or addressing from a list you furnish us and mailing from our office at no extra cost to you.



★ ★ ★

NICKEL

Practical answers to many questions about the selection, fabrication and uses of Nickel alloys are quickly available to you. This helpful information we have gathered, checked and condensed into convenient printed form. It is useful both to experienced men handling new materials or performing unfamiliar operations... and to new employees. This literature is available upon request. You are also offered the assistance of our technical staff in solving material problems arising from a temporary lack of Nickel. Our engineers are offering timely suggestions to many vital industries during the present emergency. Your request for literature or personal consultation will receive our prompt attention.

THE INTERNATIONAL NICKEL COMPANY, INC. 67 WALL STREET NEW YORK, N. Y.

NO. 3 OF A SERIES

ZINC IN DEFENSE.

PAINT SERVES DEFENSE IN:

Aircraft
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Combat Cars
Guns
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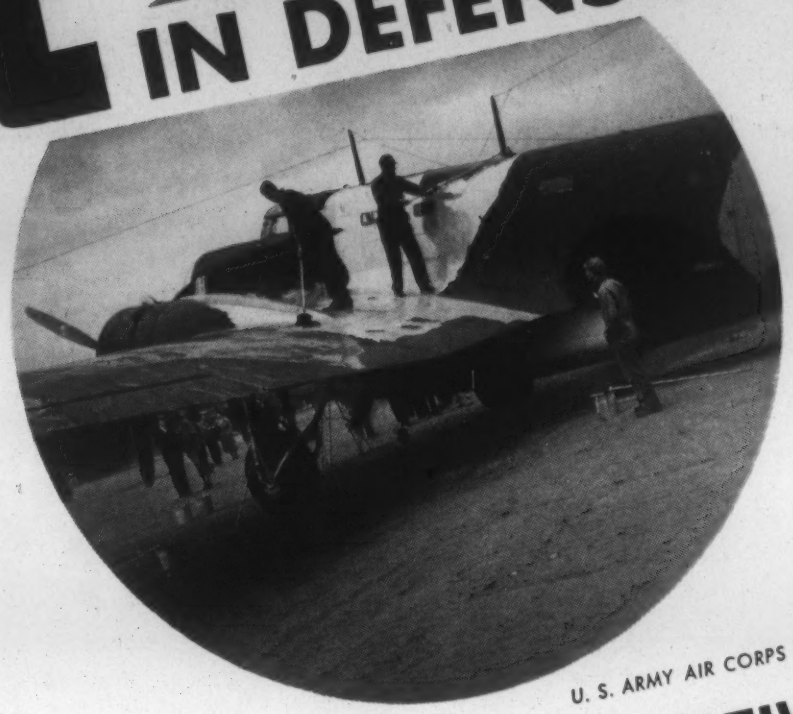
Marine Equipment
Pontoon Bridges
Scout Cars
Shells
Troop Carriers—
And In Many Other Ways



U. S. ARMY AIR CORPS PHOTO

THE ELEMENTS ARE ALSO DESTRUCTIVE!

The primary requirement of many defense items is the ability to withstand the destructive forces of war. But there are other forms of attack to be reckoned with as well—rust, chemical corrosion, and the destructive forces of the elements on land and sea. The answer to these problems is paint. Uncle Sam is faced with the biggest painting job in the history of the country—a job in which zinc pigments are playing a vital part.

No man can estimate the amount of zinc pigments needed to complete this job, but the final figure will be a staggering one. The camouflage painting, shown above, is only a small part of the story. Everything from shells to ships, from cannon to cantonments has already been covered by hundreds of exacting Government paint specifications—requiring quantities of zinc sulfide, zinc oxide, lithopone, zinc dust and zinc chromate.

Listed above are typical uses for paint coatings in defense. Zinc pigments are doing the same job in these defense paints as they have been doing in the paint industry year in and year out—protecting property and improving sanitation, too, when that is a factor. It is the increased demand for each of the zinc consuming products required in the Defense Program which is making it difficult for non-defense users to obtain all of the zinc they would like to use. This is part of the price that must be paid for national security.

PAINT
DIE CASTING
CERAMICS
BRASS
METAL SPRAYING
GALVANIZING
PHARMACEUTICALS
NICKEL SILVER
NO. 1 HULL PLATES
NO. 2 RUBBER

PAINT PROTECTS AMERICA
ZINC PROTECTS PAINT

THE NEW JERSEY ZINC COMPANY

MANUFACTURERS OF THE FAMOUS HORSE HEAD ZINC PRODUCTS

Lebanon Offers 30 Years Experience . . . and More Than 30 Alloys for Steel Castings

ON DECEMBER 11, 1911, the Lebanon Steel Foundry was organized by the two men who still head it—W. H. Worrilow, President and T. S. Quinn, Treasurer. Lebanon's thirty-year study of foundry practice (domestic and European) . . . Lebanon's thirty-year development of alloys for wider and wider ranges of casting application . . . today make Lebanon the choice of those who insist on fine craftsmanship and expert design.

The famed Circle Ⓛ now marks castings made in more than thirty different alloys. These Lebanon Steels cover a broad range of applications in many fields.

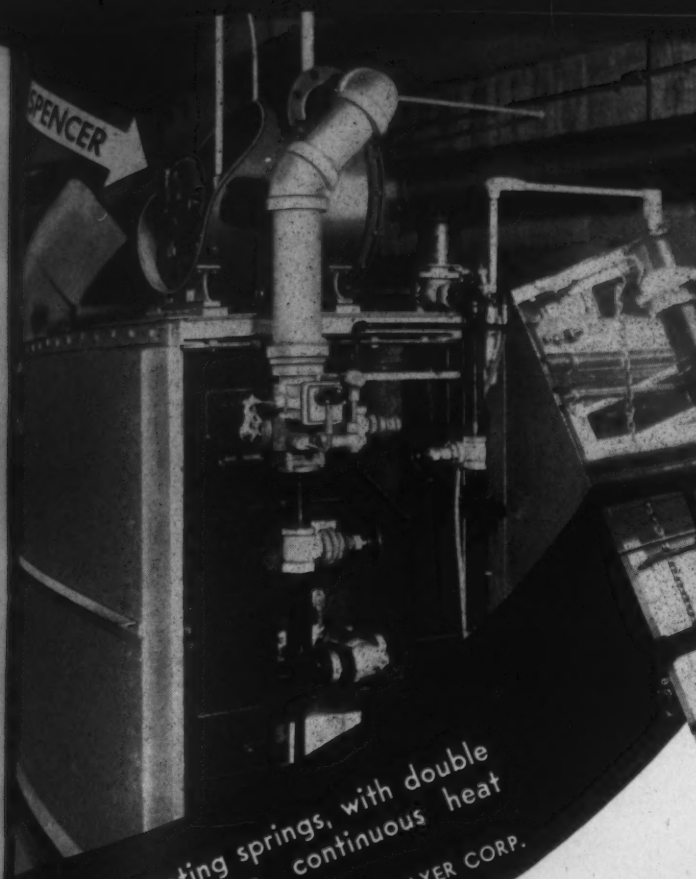
The right men using the right methods for the right kind of American defense—that is the immediate picture at Lebanon. Meanwhile, Lebanon metallurgists are studying future applications for stainless steel castings . . . and are ready to discuss significant developments with forward looking organizations.

LEBANON STEEL FOUNDRY • LEBANON, PA.

ORIGINAL AMERICAN LICENSEE GEORGE FISCHER (SWISS CHAMOTTE) METHOD

LEBANON *Stainless and Special Alloy* STEEL CASTINGS

CIRCLE L



Heat treating springs, with double end, belt-type, continuous heat treat furnace. THE CARL-MAYER CORP.

Continuous, roller-bottom, tube annealing furnace.
PENNSYLVANIA INDUSTRIAL ENGINEERS

HEAT TREATING

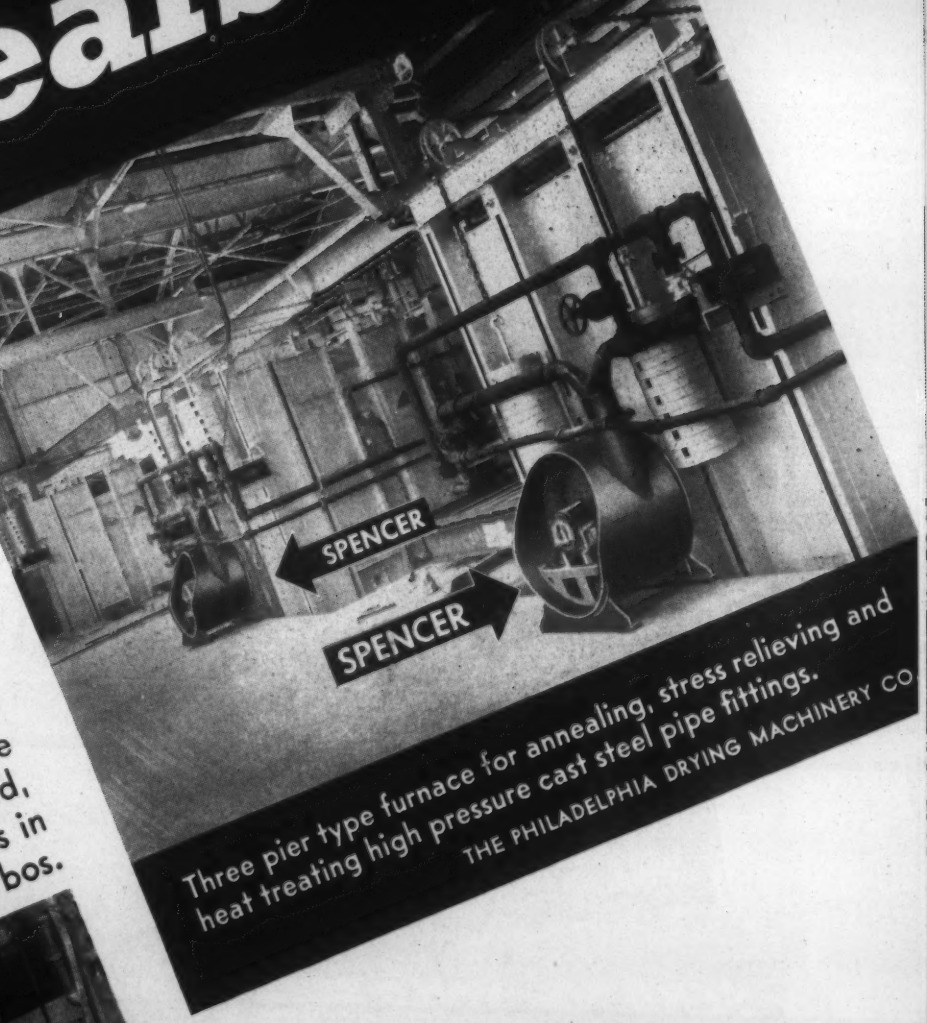
Springs-Gears-Pipe

Now is the time to scrap and save—scrap old equipment and save time, money and perhaps valuable production space. Just one new heat treating furnace may easily double the capacity of your production line.

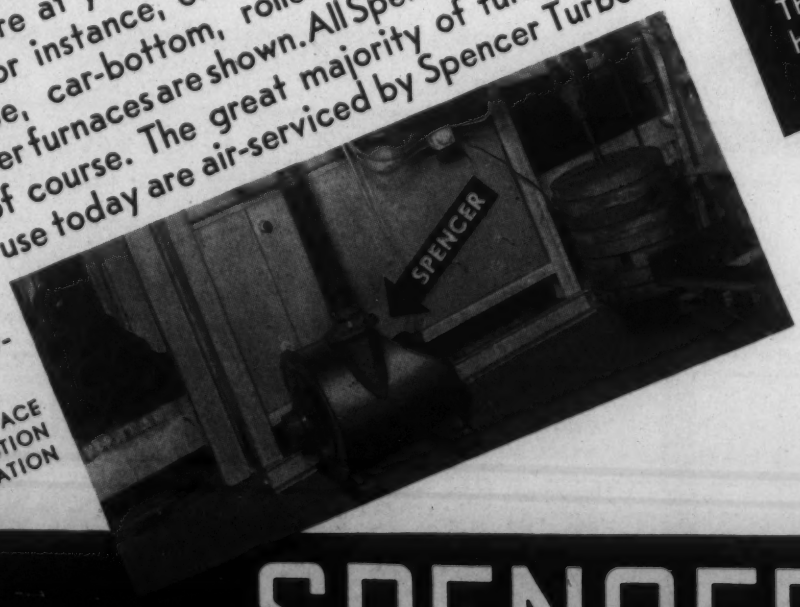
Larger furnace capacities, phenomenal improvements in loading and conveying, and a complete series of controlled atmosphere furnaces for clean hardening or bright annealing are at your beck and call.

For instance, on this page, modern, belt-type, car-bottom, roller-bottom and three pier furnaces are shown. All Spencer equipped, of course. The great majority of furnaces in use today are air-serviced by Spencer Turbos.

ASK YOUR FURNACE MANUFACTURER NOW

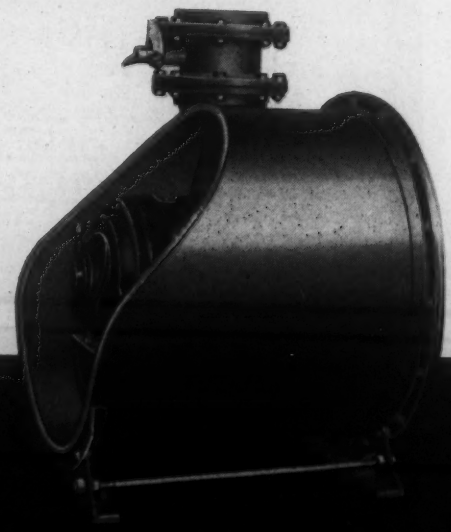


Three pier type furnace for annealing, stress relieving and heat treating high pressure cast steel pipe fittings. THE PHILADELPHIA DRYING MACHINERY CO



Car-bottom furnace, convection heated for drawing springs. SURFACE COMBUSTION CORPORATION

S-209-D



FOR
Agitation
Combustion
Exhaustion
Gas Boosters
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SPENCER
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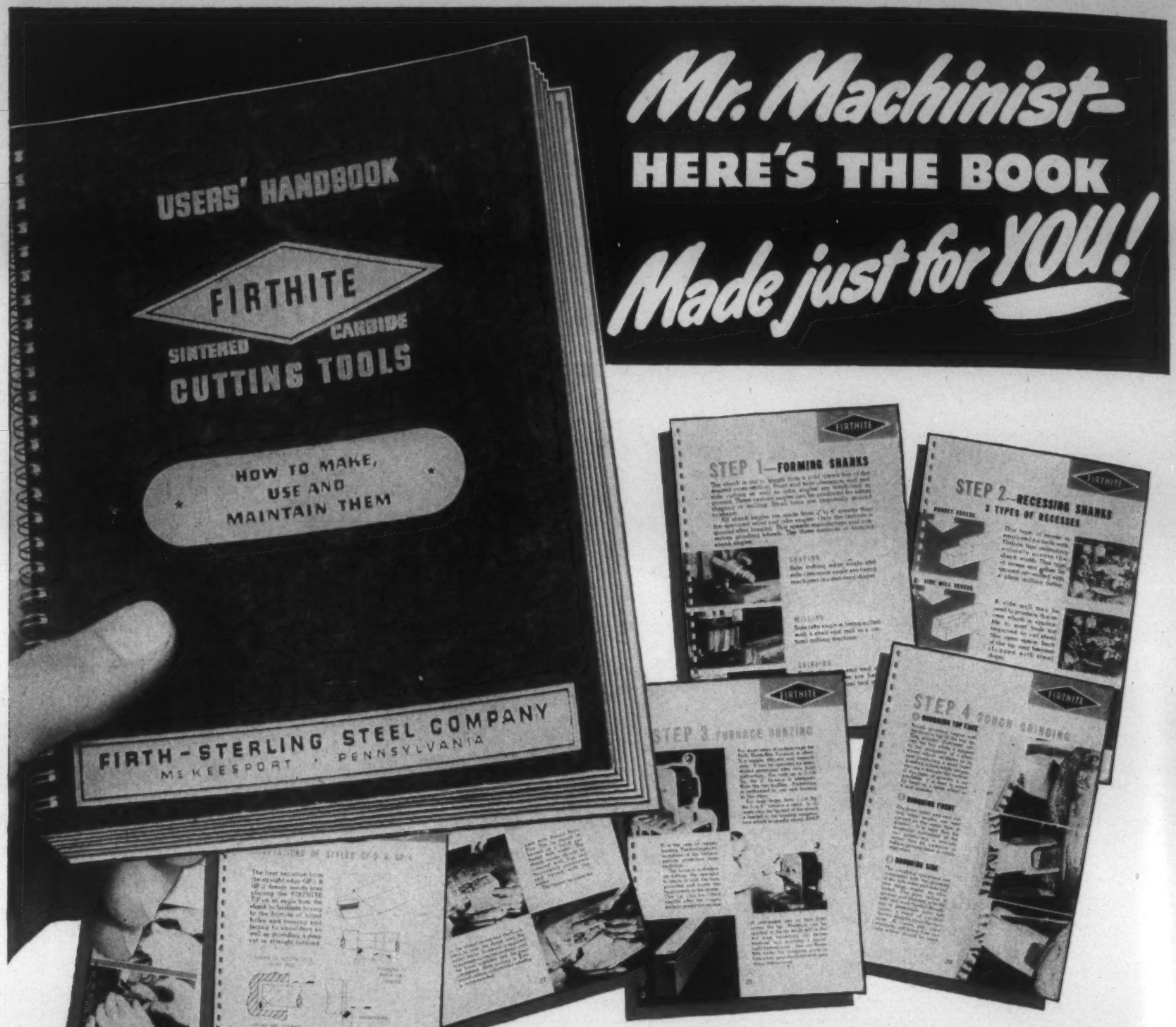
Turbo Compressors

35 to 20,000 cu. ft.
1/3 to 300 H.P.
8 oz. to 5 lbs.

THE SPENCER TURBINE COMPANY • HARTFORD, CONNECTICUT



Mr. Machinist— HERE'S THE BOOK Made just for YOU!

Nearly all the facts you need to know about the *selection, making, use,* and *maintenance* of *Carbide Cutting Tools* are packed into the pages of this 64 page, 2 color, pocket size handbook, just off the press. It's yours for the asking . . . a Firth-Sterling contribution to the National Defense effort, where practical knowledge of Carbide Tools is essential to increased production. Every machine tool operator and apprentice, tool engineer, tool room foreman, machine shop superintendent, or anyone concerned with the purchase, use and care of small tools, should have this invaluable book. A request on your company letterhead or on the coupon at the left will bring your copy by return mail. The supply is limited, so act at once.

SEND FOR YOUR FREE COPY

Firth-Sterling Steel Company,
McKeesport, Pa.

Please send my copy of the USER'S HANDBOOK OF FIRTHITE SINTERED CARBIDE CUTTING TOOLS to

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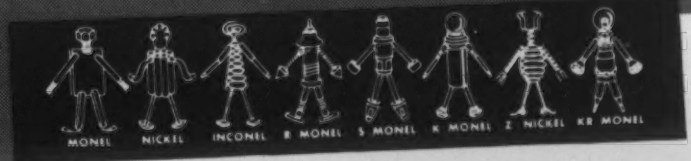
Company.....

FIRTH-STERLING STEEL COMPANY

McKEESPORT, PENNSYLVANIA

8 STRONG, RUSTLESS *Metals*



..each with a DIFFERENT PLUS!

Extra hardness, heat-resistance, non-magnetism, free-cutting and other qualities available in INCO Nickel Alloys

You doubtless know that Monel combines *strength* with excellent *resistance* to *corrosion*. But do you know that newer members of the INCO Nickel Alloy family combine varying degrees of strength with other useful properties? For example:

One of these metals is extra hard and non-galling; two are free-machining, two heat-treatable, one is non-magnetic, one especially adapted for high temperature service, while several make excellent spring materials for use under different conditions.

Knowing the *individual* characteristics of the INCO Nickel Alloys, will better enable you to meet the requirements of defense and other contracts. Write for the booklet, "*Individualized* INCO NICKEL ALLOYS." Address:

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street — New York, N. Y.

	INDIVIDUALIZED CHARACTERISTICS	AVERAGE MECHANICAL PROPERTIES					
		Condition	Tensile Strength 1000 psi.	Yield Strength 1000 psi.	Elongation in 2 in. per cent	Hardness Brinell 3000 kg.	Impact Strength Izod
MONEL* 2/3 Nickel 1/3 Copper	GENERAL PURPOSE ALLOY Corrosion Resistance, Strength, Hardness, Toughness. Attractive Silvery White Color.	Annealed Hot-rolled Cold-drawn Cold-rolled, hard-temper	75 90 100 110	35 50 80 100	40 35 25 5	125 150 190 240	105 110 95
"R" MONEL* Contains the addition of .035% sulfur—	FREE CUTTING For High Speed Machining.	Hot-rolled Cold-drawn	85 90	45 75	35 25	145 180	96 99
"K" MONEL* Contains the addition of 2.75% Aluminum	EXTRA STRENGTH AND HARDNESS comparable to heat treated alloy steel. Heat Treatable. Non-magnetic.	Hot-rolled As-rolled Hot-rolled Heat-treated Cold-drawn As-drawn Cold-drawn Heat-treated	100 150 115 155	45 110 85 115	40 25 25 20	160 280 210 290	120+ 40 56 26
"KR" MONEL*	FREE CUTTING Extra Strength and Hardness. Heat Treatable. Non-magnetic.	Hot-rolled As-rolled Hot-rolled Heat-treated Cold-drawn As-drawn Cold-drawn Heat-treated	105 150 115 155	65 105 85 115	40 25 25 25	185 280 215 290	
"S" MONEL* Contains the addition of 4% silicon—	EXTRA HARDNESS Non-galling.	Sand-cast Annealed Sand-cast As-cast Sand-cast Heat-treated	90 130 130	70 100 100	3 2 2	275 320 350	
NICKEL 99.4% Nickel	CORROSION RESISTANCE Protection for Pure Products. Magnetic below 680° F. Good Electrical Conductivity.	Annealed Hot-rolled Cold-drawn Cold-rolled, hard-temper	70 75 95 105	20 25 70 95	40 40 25 5	100 110 170 210	120+ 120+ 120+
"Z" NICKEL* 98% Nickel	EXTRA STRENGTH AND HARDNESS Heat Treatable. Excellent Spring Properties. Good Electrical Conductivity. Magnetic.	Hot-rolled As-rolled Hot-rolled Heat-treated Cold-drawn As-drawn Cold-drawn Heat-treated	105 170 120 175	50 130 90 135	35 15 25 15	180 320 220 340	120+ 25 120+ 25
INCONEL* 80% Nickel 14% Chrome Balance—Iron	HEAT RESISTANCE Retains Strength. Resists Oxidation. High Corrosion Resistance.	Annealed Hot-rolled Cold-drawn Cold-rolled, hard-temper	85 100 115 135	35 60 90 110	45 35 20 5	150 180 200 260	120+ 110 85

*"MONEL" and other trade-marks which have an asterisk associated with them are trade-marks of The International Nickel Company, Inc.

INCO NICKEL ALLOYS

MONEL • "K" MONEL • "S" MONEL • "R" MONEL • "KR" MONEL • INCONEL • NICKEL • "Z" NICKEL

Sheet...Strip...Rod...Tubing...Wire...Castings

NO. 9

ALUMINUM, DEFENSE, AND YOU

SIX MORE PLANTS IN FIVE STATES ON THE WAY

DEFENSE PLANT CORPORATION OWNS THEM. We've been designated to build them . . . fast.

Actually, when the names went on the dotted lines of the contract on August 19, we had already placed more than $16,000,000 worth of orders for some of the equipment and materials it takes longest to make and get.

FIVE OF THESE PLANTS will smelt aluminum. Their combined capacity is planned for more than 500,000,000 pounds a year, which is greater than the nation's entire production of aluminum in 1940. Locations: Massena, N. Y., Spokane, Wash., Troutdale, Ore., Los Angeles, and in the State of Arkansas.

The sixth plant will refine alumina from bauxite. Its billion-pounds-a-year capacity adds 58% to the nation's alumina capacity. It will be located at Bauxite, Arkansas.

HOW GOES CONSTRUCTION? At this writing, as fast as title is secured to the sites, contracts are being let for grading and foundations so as to be ready for the structural steel, which is coming as rapidly as it can be gotten.

What is more important, the aluminum plants are scheduled to deliver ingot by the summer of 1942; the refining plant to deliver alumina in early summer, 1942.

WE'VE ASSIGNED a large staff of men full time to headquarters engineering, purchasing, and accounting on this government building job.

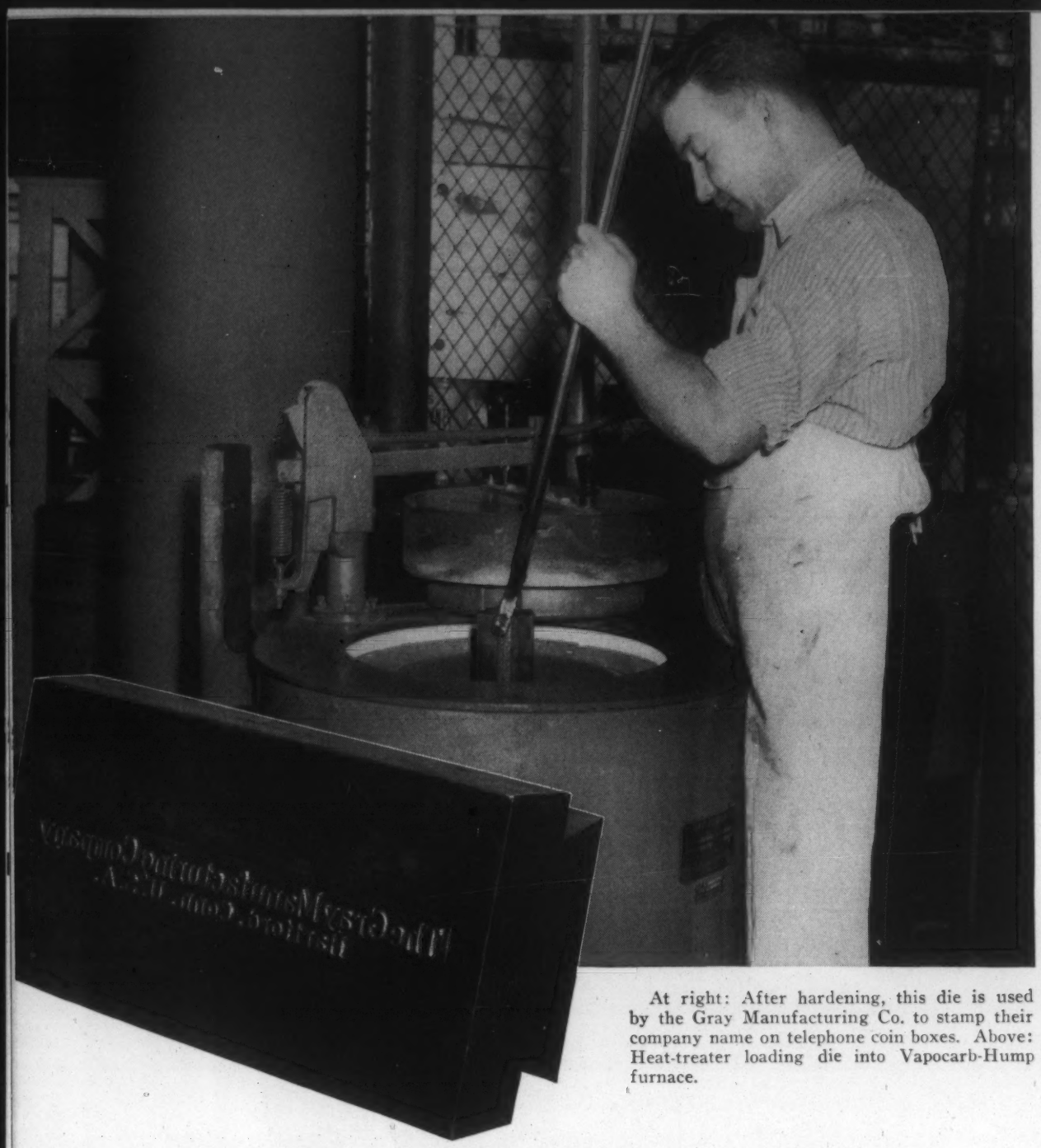
We're sending competent and experienced management men out on these jobs as superintendents and other staff executives on construction, and for subsequent operation of such of these plants as we are designated to operate.

EVERY KNOWN IMPROVEMENT in design and construction and equipment is being incorporated in these plants. We intend that every dollar that will be spent shall be the best dollar's worth that experience can build. We do not make one cent of profit from this assigned job of construction.

We think we know how to get the government value-received for its money, because we are completing the expenditure of more than $200,000,000 of our own money in an expansion program which started after the beginning of the present war. Some of this expenditure is in new alumina and aluminum plants which will bring our own Alcoa capacity up to more than 700,000,000 pounds a year. The remainder is in tremendous expansion of facilities for fabricating every form of aluminum.

DEFENSE, GENTLEMEN, is getting its aluminum.

ALUMINUM COMPANY OF AMERICA



At right: After hardening, this die is used by the Gray Manufacturing Co. to stamp their company name on telephone coin boxes. Above: Heat-treater loading die into Vapocarb-Hump furnace.

FINELY-ENGRAVED DIES

Deserve Vapocarb-Hump Hardening

The question of how to handle this die in the hardening furnace might well be a problem in many heat-treats. Its original dollar-a-pound cost, for the steel, was of course redoubled several times as highly-skilled die sinkers labored over it, so that a bit of uneasiness as to furnace operation might well have been expected.

But that wasn't the case with this tool. The Gray Manufacturing Company, makers of telephone coin-boxes, use the Vapocarb-Hump hardening method on all tools like this, and there's no reason for uncertainty in such cases.

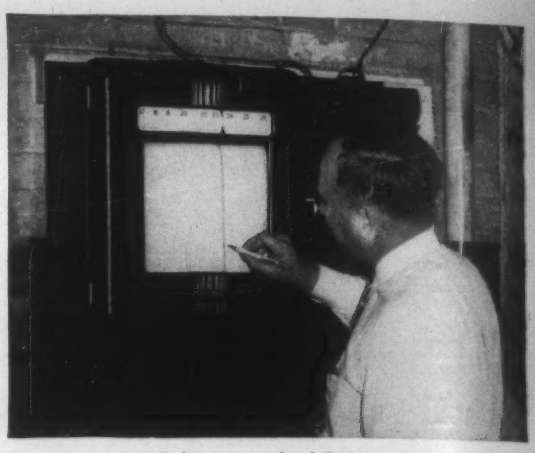
For the heat-treater has, in the Vapocarb-Hump Method, everything he needs to assure successful handling of the die in the furnace. He can shut the air away entirely, by means of Vapocarb atmosphere, thus eliminating all possibility of scale, pits, soft spots, and decarburization. He can see the temperature of the die, the temperature of the furnace, and the difference between them, and can control this latter to prevent warp. And the die itself will tell him when it enters the critical, and when it leaves, so that he can decide just when to quench it to secure the desired depth of hardness. Undaunted by the high value of the tool, the heat-treater can thus proceed to harden it so as to give it the longest possible life—many years, in this case.

If your plant suffers from erratic performance of tools—even of low-priced ones—Vapocarb-Hump hardening can probably help you. Ask for Catalog T-621.

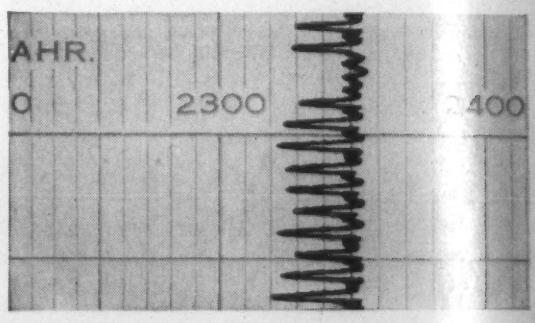
Morse Improves Heat-Treatment by Using Micromax Pyrometer

Sensitive and accurate control of temperature is of course not new to the Morse Twist Drill & Machine Co., but it is more easily secured now than ever before, in the heat-treatment of high-speed steels, because the Company is using a Micromax Pyrometer, with a Rayotube as temperature detector.

Milling cutters and similar tools are preheated before they enter the Company's Hayes high-speed-steel furnace, which the Micromax is holding constant at the high hardening temperature. A batch of 6 tools, plus this holder, weighs only a few pounds. Nevertheless, when it enters the furnace, the Micromax pyrometer is so sensitive that its record actu-



Foreman examining record of Micromax Recording Controller. Below is full-size sample of record, showing "spikes" caused by putting batches of drills into furnace. Note sensitivity and speed of control.



ally moves off at a right angle; it seems almost to jump. And the instrument simultaneously calls for more heat energy. As temperature rises in response to this call, the Micromax watches carefully, and shuts down on the supply in such a way as to return temperature to the control point with promptness and precision. So successful is the control that rejects due to heating are almost unknown.

As the chart shows, the cycle of off-temperature-and-back is controlled so quickly and accurately that it's represented by a single sharp spike on the record. Each spike thus indicates one batch of tools "signing" into the furnace, automatically, for accurate heat-treatment. The record guides both heat-treater and foreman, and is always ready to help convince either management or customer of the quality of heat-treatment.

The Micromax sensitivity and responsiveness, which perform somewhat spectacularly here, are available for any type, size or make of furnace, or almost any other heat-using equipment. If you have a temperature-control problem, outline it and we will send the appropriate catalog.

Jrl Ad ENT-0600C(35)

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	CREEP PERCENT PER HOUR		
STRESS—lbs. per sq. in.	Common or Commercial Lead	Chemical or Copper Lead (.06% Cu)	Calcium Lead (.05% Ca)
200	5×10^{-5}	0.4×10^{-5}	
300	3.5×10^{-4}	1.5×10^{-5}	
400	11×10^{-4}	3×10^{-5}	5×10^{-6}

The above results were obtained at room temperature. Rate of creep increases with rise in temperature and at 150°F Chemical or Copper-bearing lead would show the following:

STRESS—lbs. per sq. in.	CREEP PERCENT PER HOUR
200	6×10^{-4}
300	5×10^{-3}
400	2.3×10^{-2}

Antimony and tin, in amounts of 1 to 3%, while tending to strengthen lead, appear to impair rather than improve creep resistance, particularly at stresses of 400 p.s.i. and lower.

	TIME FOR 1% EXTENSION	
	400 lbs. per sq. in.	300 lbs. per sq. in.
Common lead	60 days	110 days
Common lead + 1% Sb	20 days	60 days
Common lead + 3% Sn	30 days	80 days

FATIGUE, or failure under repeated cycles of reversed bending stress, may be materially influenced by the addition of other elements to the lead.

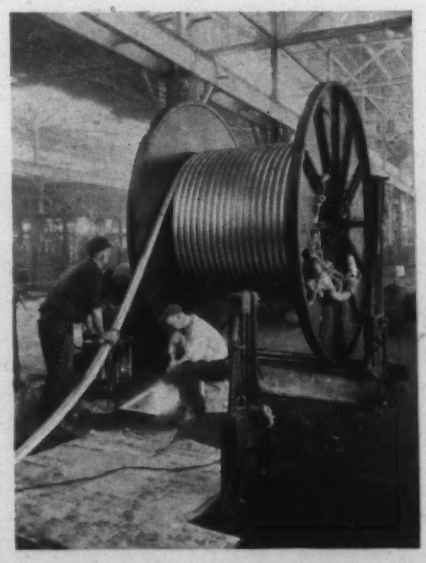
	ENDURANCE LIMIT AT 10,000,000 CYCLES OF STRESS	
	700 r.p.m.	865 r.p.m.
Commercial lead	700 p.s.i.	
Commercial lead + 2% Sn	700 p.s.i.	
Commercial lead + ¾% Sb	1200 p.s.i.	
Commercial lead + .04% Ca	1500 p.s.i.	
Chemical lead		725 p.s.i.
Copper lead (.06% Cu)		725 p.s.i.
Tellurium lead (.045% Te)		1000 p.s.i.

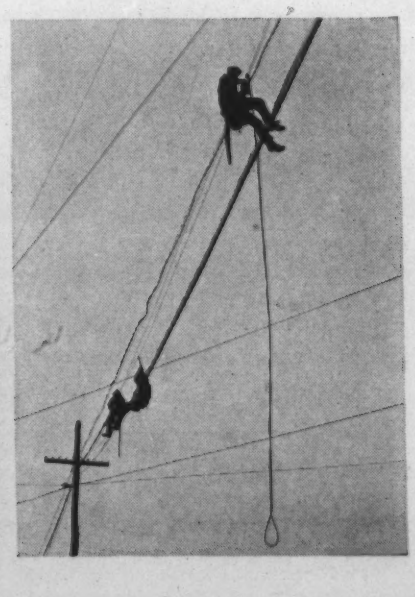
In oil-filled power cable and lead pipe or sheet installations, subjected to low, steady pressure, creep is a factor to be considered.

(Photo at right: 115,000 volt, oil-filled submarine cable after application of lead sheath.)

Repeated stresses caused by temperature expansions, or by vibrations, may cause fatigue failure.

(Photo at far right: Aerial communication cable subjected to cyclic stressing.)





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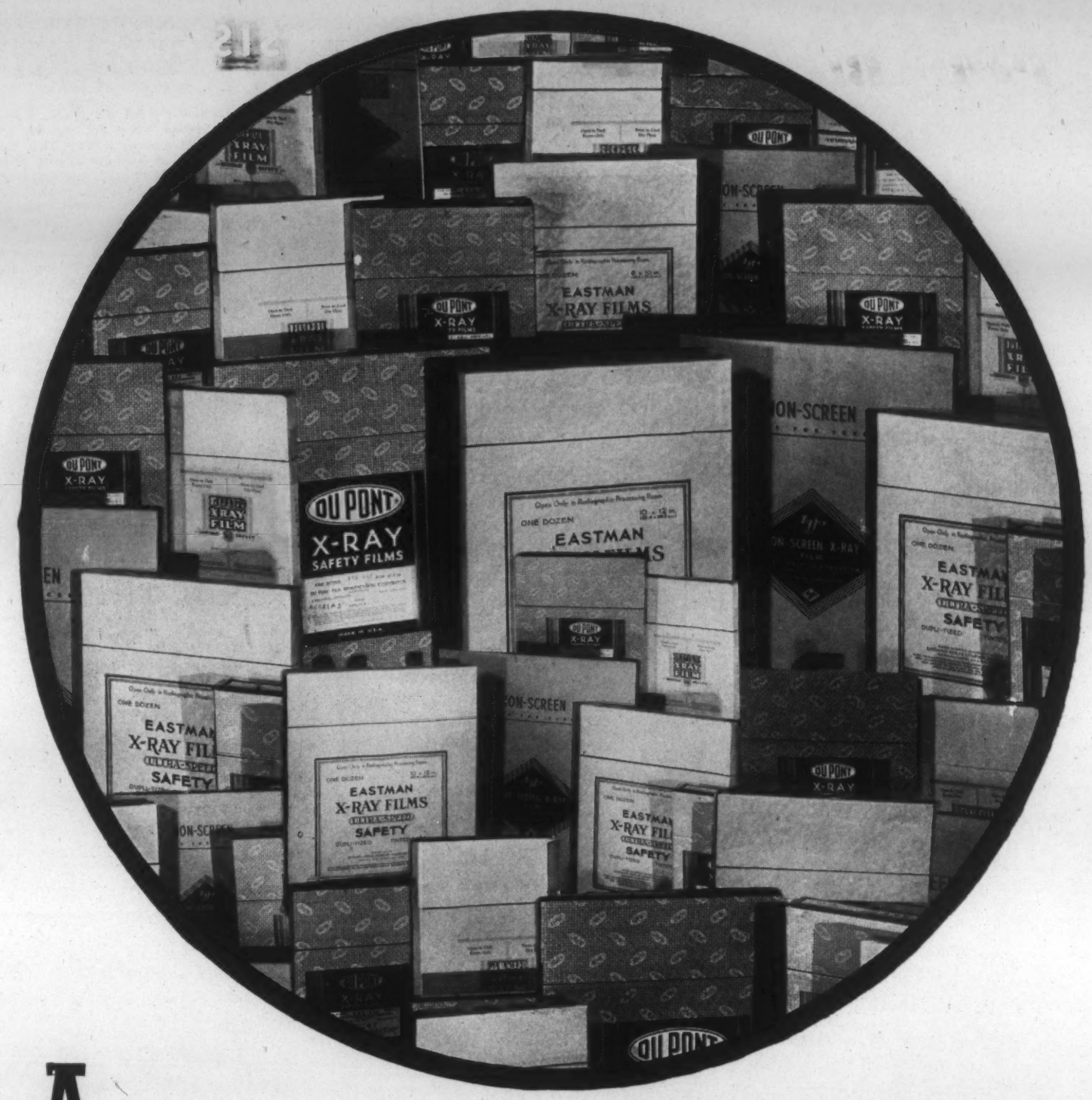

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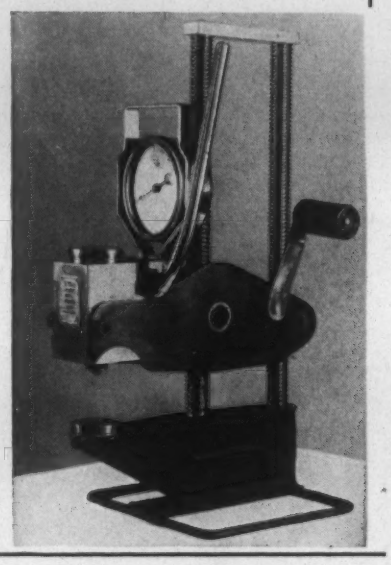

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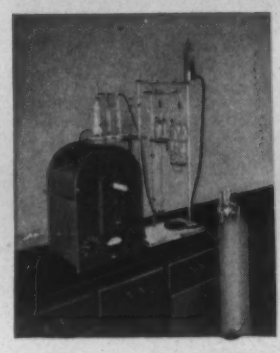

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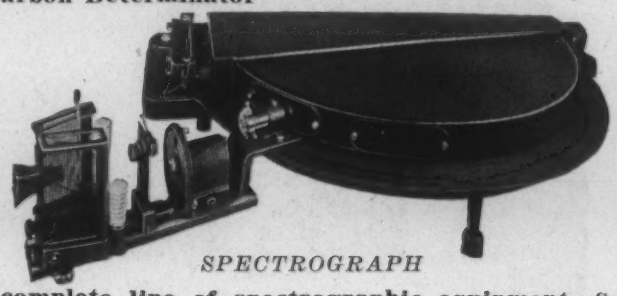

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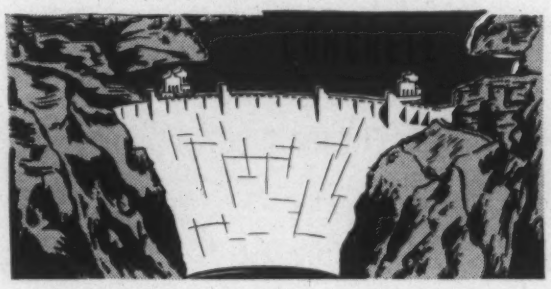

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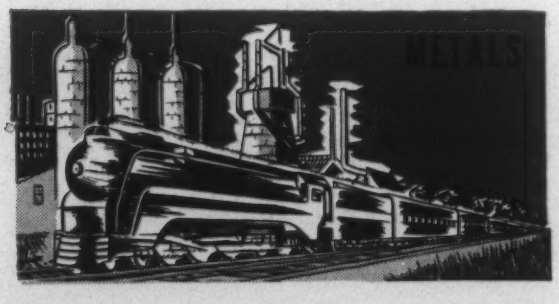

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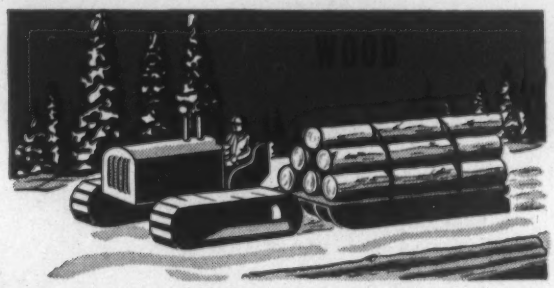

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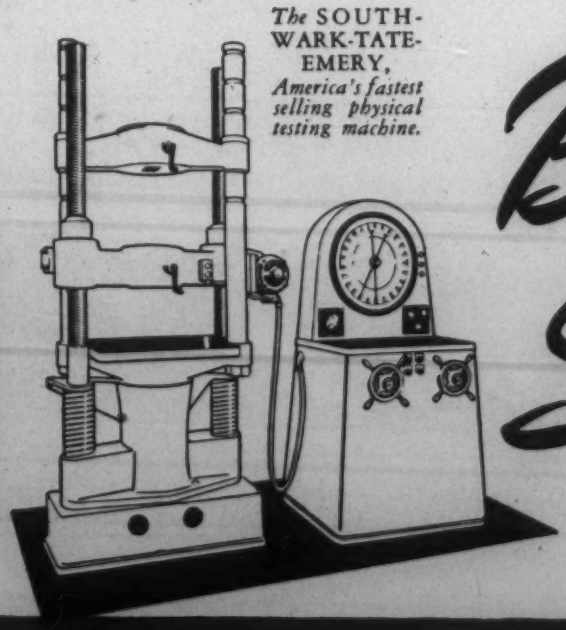

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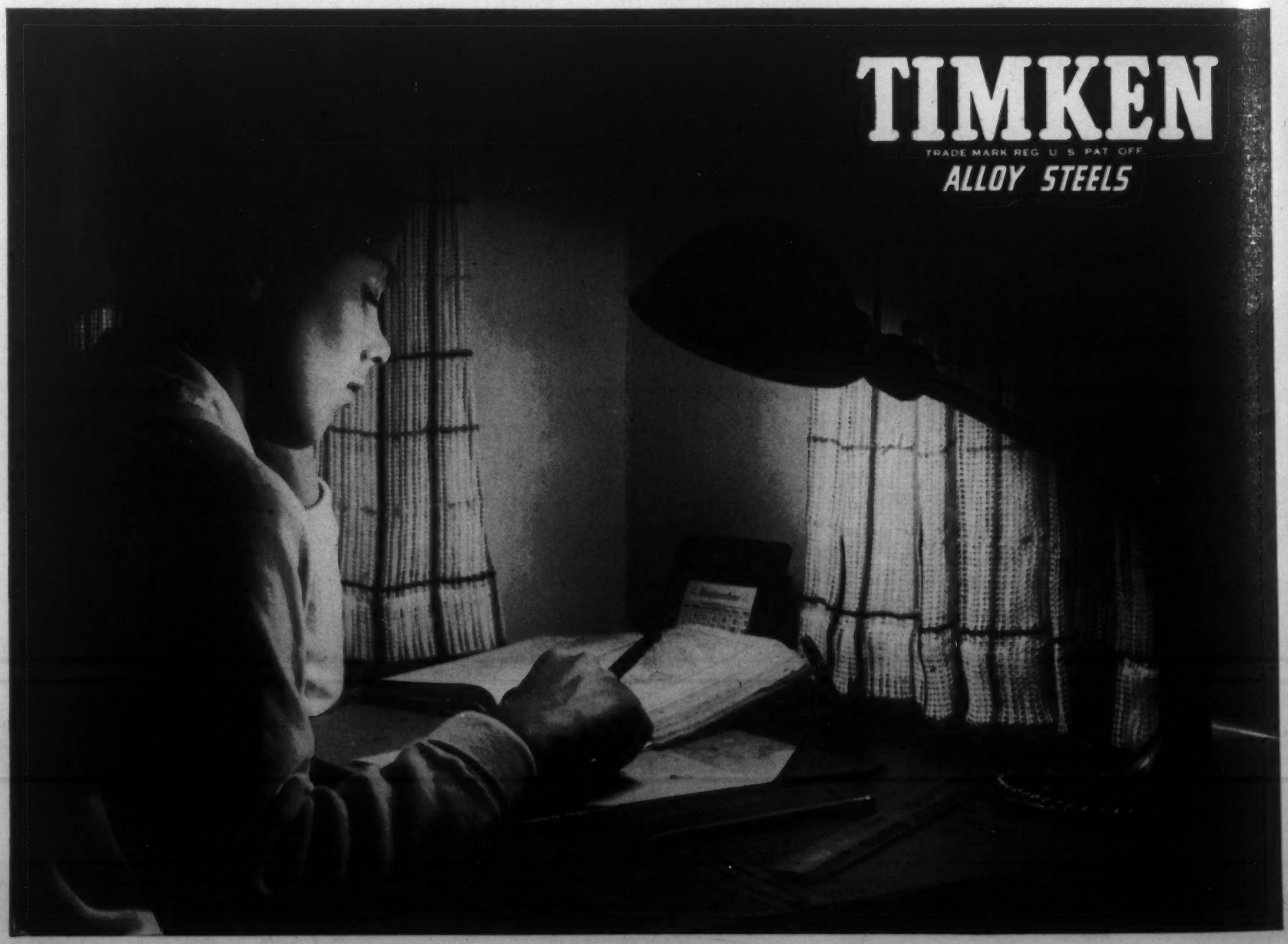

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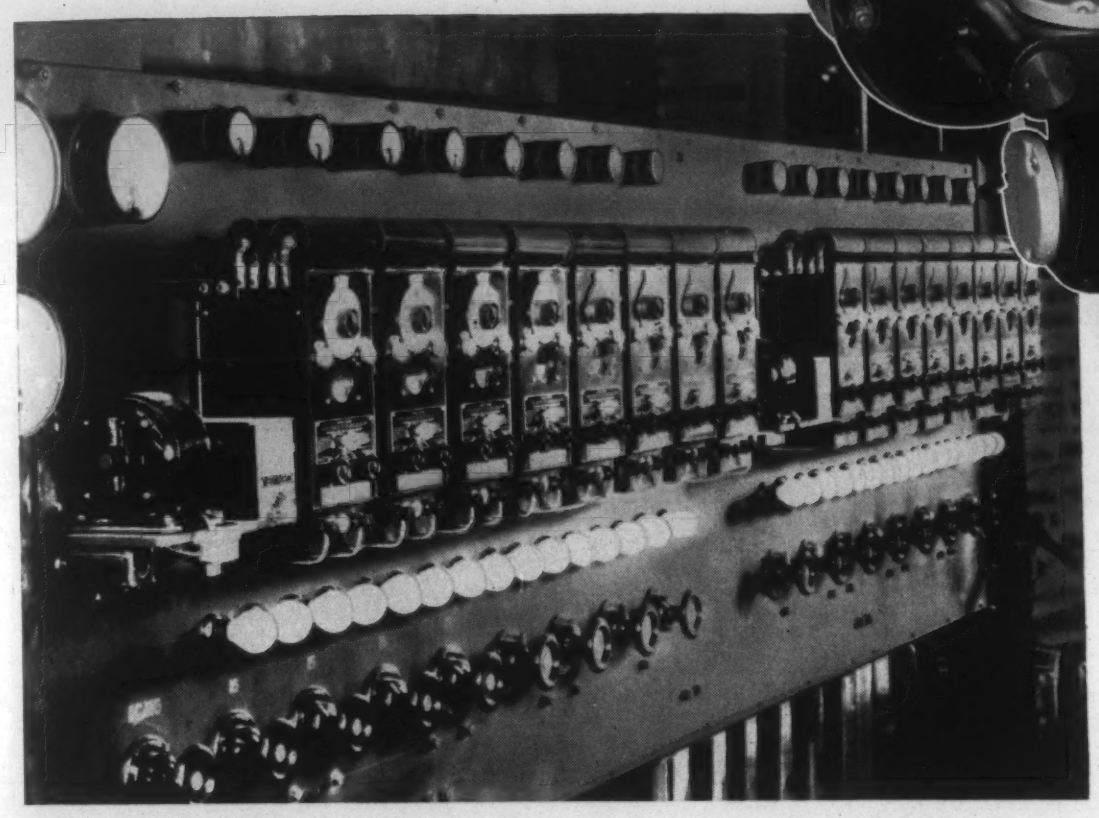

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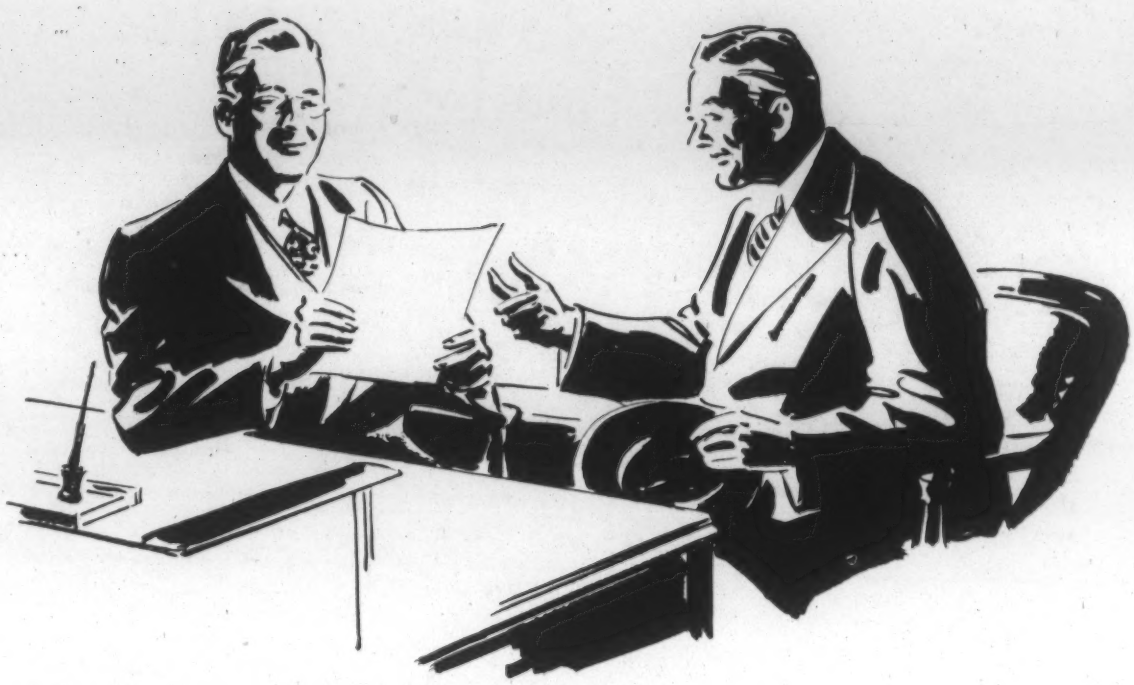

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